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...REPORT...

ON THE

Marble, Slate and Granite Industries of Vermont,

BY

GEORGE H. PERKINS, Ph. D.,
State Geologist.

RUTLAND:
THE TUTTLE COMPANY, OFFICIAL PRINTERS,
1898

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RUTLAND:
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OFFICE OF STATE GEOLOGIST,
BURLINGTON, VT., October 15, 1898.

To His Excellency, Josiah Grout, Governor:

SIR:—In accordance with the requirement of Section 2, Act No. 7, 1896, I herewith present my Report on the quarrying industries of Vermont. By your kind permission I have been allowed to delay publication somewhat beyond the required time on account of my very recent appointment. It is needless to call attention to the haste with which the field work, preparatory to the Report, as well as the writing of the manuscript, have been done. Only about six weeks were available for both, and I have endeavored to make the most of this brief period.

Very respectfully,

GEORGE H. PERKINS.

REPORT.

EARLY last summer the State Geologist, Rev. G. W. Perry, on account of continued and serious illness, resigned, and on the seventh of September I received, from Governor Grout, my appointment to the office. I at once proceeded to carry out, as far as possible, the requirements of the laws defining the duties of State Geologist, especially those of Sec. 1, of Act No. 7, of the session of 1896, viz.: "The State Geologist shall, during the next two years, personally inspect the mines and quarries now in operation within the State; also deposits of minerals of economic value, which have not been opened or developed;" as well as the following sections of the same act. Obviously it was not at all possible to comply fully with the requirements of the above act within the time remaining before the session of the General Assembly, to which a Report was to be submitted. Some limitation being thus absolutely necessary, I concluded to confine my investigations and field work to the three greatest of our mineral industries, marble, slate and granite, and after several weeks of very active field work, I found that it was not practicable to visit all of those quarries from which these materials were obtained. Most regretfully were quarries of soapstone and talc, mines of copper, beds of clay, ochre, lignite, iron ore, manganese, and other interesting minerals wholly ignored. All of these are well deserving of a full Report, but this is out of the question at present.

It hoped that the present Legislature will make such appropriations for the work of the State Geologist as will make a continuance of the work begun in this Report possible. This publication is not to be regarded as anything more than preliminary to a much fuller report, of more complete investigation of the mineral resources of our State, which investigations can be made, and a Report which would be of great value, prepared at a very moderate cost, during the next two years. It is neither to the credit nor advantage of Vermont that no such report exists, and that full, accurate and scientific information respecting the quarries, mines and rock formations of our State is nowhere to be found. The large Report on the Geology of Vermont, in two quarto volumes, published in 1861, contains much valuable matter, and much that is not very valuable, but it does not give such information as any one who is seeking to make profitable investments would require. And during the thirty-seven years that have passed since that Report was issued, no Geological Report has been authorized or published by the State until the Act above referred to, passed by the Legislature of 1896.

As has been stated, the illness of Mr. Perry, who had collected considerable material for the purpose of preparing a Report, prevented him from accomplishing his purpose. Having no access to this material, the writer could only attempt to carry out the intent of the act as well as possible in the very few weeks at his disposal. During the month of September I visited and examined about seventy-five quarries, but none of them received the careful attention which should have been given to them, and it is with some reluctance that I present a Report which necessarily falls far below what it might have been had a few months more been available. On this account it is important that this reconnoisance, for it has been little more, may be followed by a thoroughly carried-out campaign during the next two years. Such a geological study of our mineral resources, followed by a full and well illustrated Report, would not only be interesting to those already interested in our quarries and mines, but it should awaken interest in many quarters now indifferent through lack of information, and, therefore, should do something to increase the resources and wealth of Vermont.

Vermonters should realize that there is no State in the Union which has, in proportion to area and population, so great wealth and resources in beds of useful rocks. If properly developed during the next ten years, the marble, slate and granite industries of Vermont will surpass those of other States. Vermont is known far and wide as an agricultural State, but we can scarcely hope to remain in the front rank in this respect. Our manufactures are varied and important, but we cannot rival many another State in these industries. When, however, it comes to the possession of vast beds of marble, slate and granite, and the production of stone from these deposits, our future outlook is most encouraging. The existence of such riches being assured, the first rational step toward developing and utilizing them is that which leads to a knowledge of what we have and to giving others, those outside the State, who have needed capital, some knowledge of what there is awaiting their investments. I do not think that there is a State in the Union which has greater need of a geological survey, or which would receive greater benefits from it than our own. Such a survey, if properly conducted, is really taking an inventory, an account of stock, of the natural resources of the region examined, and I believe that such surveys have almost always been of very great benefit to the State carrying them on, benefit far beyond all cost to the State. Vermont is behind most States in investments in scientific work, and she has suffered accordingly. Where such investment has not borne abundant fruit, the reason has been that scientific work has been entrusted to unscientific workmen, instead of being given to those properly prepared for it. There is very much work to be done in Vermont in the way of geological investigation. Besides the quarries and mines, there are most interesting beds of fossiliferous rocks along the shores of Lake Champlain, and equally interesting masses of crystalline and metamorphic rocks in the Green Mountains and from them on to the Connecticut river, which presents many problems to the scientific investigator, and which should receive far more thorough study than has hitherto been given to them. Aside from the very valuable, but limited, studies of President Brainerd and Professor Seely, on the Marble Border of Vermont, and on the Calciferous and Chazy beds of the Champlain Valley, of Mr. Walcott on the Cambrian beds, of Mr. T. N. Dale on portions of Rutland and Bennington counties, of Mr. S. P. Baldwin and Dr. C. H. Richardson on the Pleistocene of the Champlain Valley, of Dr. Richardson on Washington county, and the older but all-important work of Rev. A. Wing on the Rutland marbles, little has ever been done to really elucidate the many difficult problems which Vermont geology presents. It is no disparagement of the above named writers on Vermont geology to say their work is little more than the beginning of what should be done*.

*** The following list includes most of the papers on the Geology of Vermont which have been published during the last fifteen years :**

Geological Sections Across New Hampshire and Vermont. C. H. Hitchcock, Bulletin American Museum of Natural History. Vol I., p. 155.

Notice of Geological Investigations Along the Eastern Shore of Lake Champlain. Conducted by Ezra Brainerd and H. M. Seely. R. P. Whitfield, Bulletin Am. Mus. Nat. Hist. Vol. I., p. 293.

The Marble Border of Western New England. By Ezra Brainerd and H. M. Seely. Proceedings Middlebury Historical Society. Vol. I., Part II.

The Winooski Marble of Vermont. G. H. Perkins. Am. Naturalist. Vol. XIX., p. 128.

Studies on Cambrian Fauna. C. D. Walcott. Bulletin U. S. Geol. Survey, 30.

The Original Chazy Rocks. E. Brainerd and H. M. Seely. Am. Geologist, November, 1888.

An Account of the Discoveries in Vermont of the Rev. A. Wing. J. D. Dana. Am. Journal Science and Arts. Third Series. Vol. XIII., pp. 332, 405. Vol. XIV., p. 36.

The very great importance of one branch of the geological work of which I have been writing, that which includes the deposits of useful and monumental stone and the quarries which are located upon them, is best understood, perhaps, when we consider that Vermont, though one of the smallest States in extent of surface, yet stands first in the value of marble produced, second in slate and second in granite, and third in the total of all quarry products, only Pennsylvania and Ohio producing more. The total value of all the stone produced in Vermont in 1897 is, according to data collected by Mr. Perry, $3,598,399. The capital invested was, in 1897, over $12,000,000, the exact amount I cannot ascertain, but I am sure that it is more than the above named sum. Over five thousand men are employed in the 167 quarries, and there are others not reported. It is very gratifying to learn from nearly all the quarries investigated that the demand for Vermont stone is increasing, and also that the supply is far from being exhausted. Many deposits have been scarcely touched.

Perhaps it may be well to state that while I shall find it convenient, even necessary, to mention certain quarries and quarrying firms, this is done in no way to advertise them, but only to make known, as best I can, the re-

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The Calciferous Formation in the Champlain Valley. Ezra Brainerd and H. M. Seely. Bulletin Am. Mus. Nat. Hist. Vol III., p. 1.

Observations on the Fauna of the Rocks at Fort Cassin, Vt. R. P. Whitfield. Bulletin Am. Mus. Nat. Hist. Vol. III., p. 25.

The Chazy Formation in the Champlain Valley. Ezra Brainerd. Bulletin Geological Society of America. Vol. II., p. 293.

Structure of the Ridge Between the Taconic and Green Mountain Ranges in Vermont. T. N. Dale. Fourteenth Report U. S. G. S., p. 531.

The Pleistocene History of the Champlain Valley. S. P. Baldwin. Am. Geologist. Vol. XIII., p. 170.

The Chazy of Lake Champlain. Ezra Brainerd and H. M. Seely. Bulletin Am. Mus. Nat. Hist. Vol. VIII., p. 305.

Description of New Species of Silurian Fossils from near Fort Cassin, Vermont, and Elsewhere on Lake Champlain. R. P. Whitfied. Bulletin Am. Mus. Nat. Hist. Vol. IX., p. 177.

sources of the State and what is being done to develop them. I greatly regret that the brevity both of the time for visiting and studying the quarries, and also for writing this Report, makes it quite impossible to do justice to many important quarries. One of the many reasons why a more complete Report should be prepared in the near future, is that the deficiencies and unavoidable errors of this may be corrected. On this account the State Geologist will be very glad to receive any information respecting quarries or mines of this State.

Besides the great quarries of marble, slate and granite, Vermont has extended limestone quarries, a few of soapstone or steatite, one of talc of considerable value, beds of ochre, clays of various kinds, as well as mines. These lesser but important interests should by no means be neglected. A full Report should include them all, but for reasons already given they are not included here.

THE MARBLE INDUSTRY.

Vermont has long been famous for the quantity and quality of the Marble produced. The pre-eminence of Vermont in this respect is shown by the fact that in 1890 the marble obtained from the quarries in the United States was valued at $3,488,120, and of this Vermont produced $2,169,560, and I presume these relative values would not be greatly changed by more recent figures, which I am unable to obtain. In absolute quantity, New York exceeds Vermont, but much of its product is fitted only for use as a building stone, while much of our marble can be used in statuary and monuments, and therefore has a much greater value. No other State, nor the whole United States, can at all approach Vermont in the quantity and value of the finest grades of marble.

By far the largest part of the marble quarried in Vermont is obtained in Rutland County, though there are a few quarries just south, in Bennington County, and

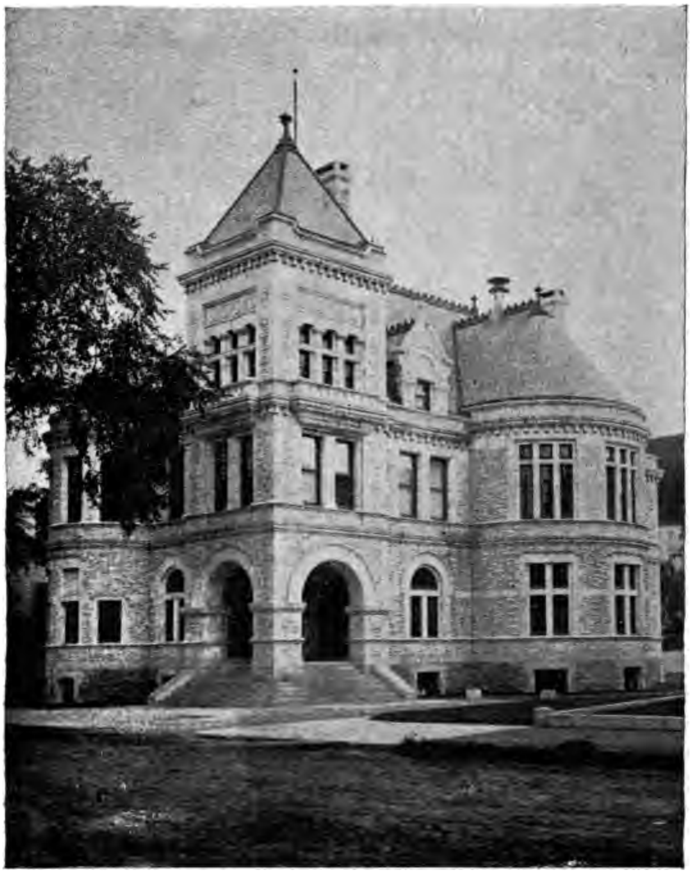


Figure 1. POST OFFICE AND COURT HOUSE, MONTPELIER.
Built of Sutherland Falls Marble.

north, in Addison. There are deposits, not now worked, in Chittenden, and quarries of the beautiful Champlain marbles in Franklin County. There are, in all, between thirty and forty quarries, in which are employed over two thousand workmen, the Vermont Marble Company alone employing 1700. The deposit of marble, so far as now known, begins at the south at Dorset Mountain, and extends northward, in a narrow belt, through Wallingford, West Rutland, Proctor, Pittsford and Brandon, to Middlebury, and there are unworked beds considerably north of the latter place. These are true marbles, metamorphosed limestones. The marble of Swanton and other localities is of different origin, and geologically is not true marble, though just as valuable as if it were, possibly more so. As has already been noticed, the great advantage which Vermont has over other marble producing States is seen in the quality of her marble. Marble good for building is found in many localities, but it is worth only from 75 cents to $2.00 a cubic foot, while marble suitable for monuments sells at from $5 to $7, and statuary brings $12. As the cost of quarrying a block of common building marble is the same as if it were of finer grain, it is obvious that a quarry, or deposit of the finer stone is greatly to be desired. Of this finer marble Vermont produces more than seven times as much as does any other State. Nevertheless the use and increasing use of marble as a building stone is not unimportant, for much of our marble is of value chiefly for this purpose, either because of its texture or color. That marble, especially when "rock-faced," is capable of being used as a building stone, with good effect, can be easily proved by reference to the U. S. government building in Montpelier, a cut of which is, through the courtesy of the *Montpelier Watchman*, here given (Figure 1), as well as a view of the Water Tower at Fort Ethan Allen (Figure 2), which, like the building mentioned, is of Sutherland Falls marble. This latter view was furnished by the Vt. Marble Company. Many very fine buildings in various parts of the country are constructed of the Rutland marbles.

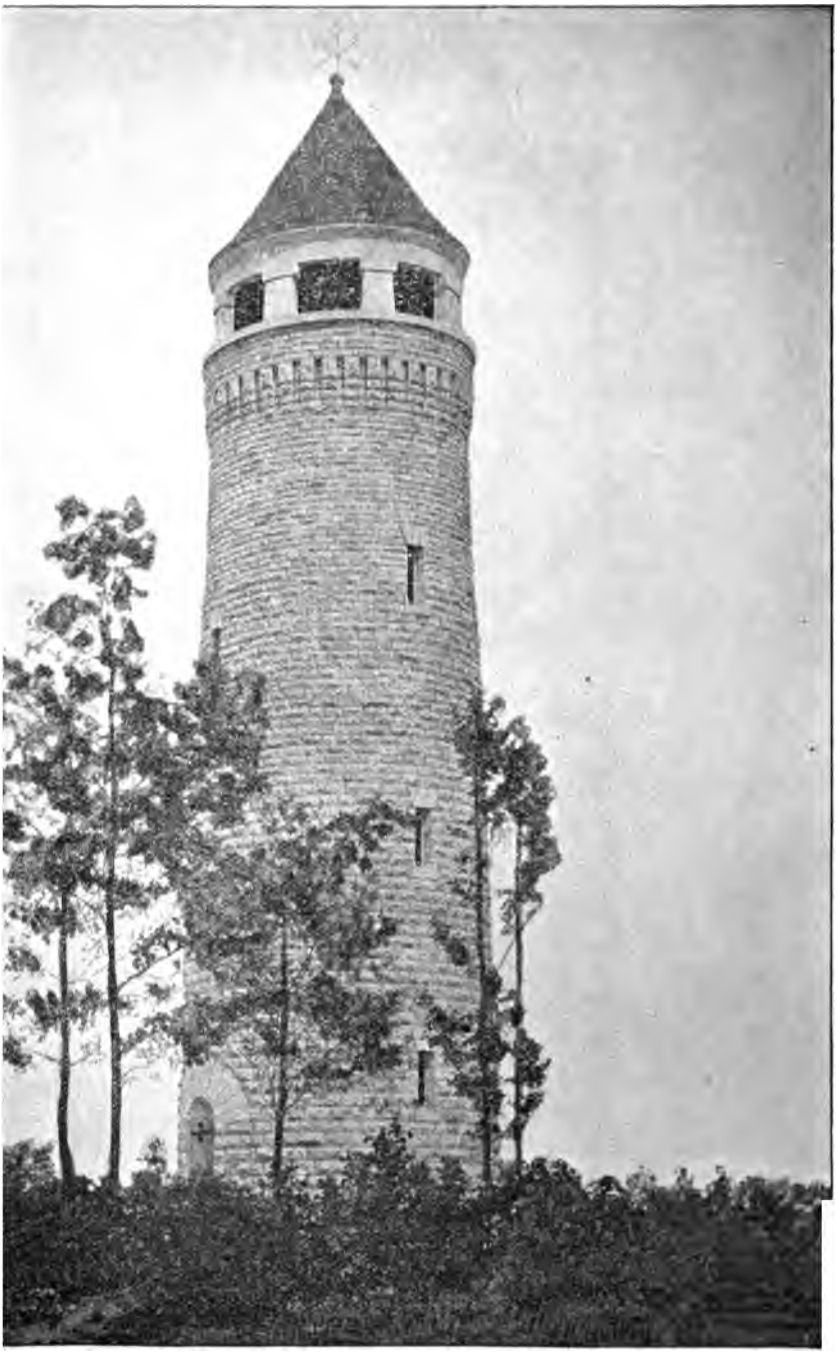


Figure 2 WATER TOWER, FORT ETHAN ALLEN.
Rockfaced Sutherland Falls Marble.

Beginning our survey of the Marble region at Dorset, we find high up on the sides of Dorset Mountain a group, or belt of quarries, some of them not at present worked, which are capable of producing a large amount of fine marble. The largest and most productive quarry is known as Freedly's, carried on, as is the mill at the base of the mountain, by Messrs. J. K. Freedly & Sons. This is a very interesting quarry and one of the oldest, having been worked, it is said, since 1803. It is charmingly located on the east side of the mountain about 1000 feet above the beautiful valley. Dorset Mountain is capped by a mass of slate about 500 feet thick, and immediately below this is a great mass of marble, which is several hundred feet thick in some parts of the bed, though much less in other parts. Beneath the marble are great beds of limestone. The marble is rather more coarsely crystalline than that at West Rutland, and some of the layers are rather soft, but most of it is very hard and it is said to be durable. In the Freedly quarry the color varies from pure white, through several shades, clouded and veined, to dark bluish gray. The quarry is partly open and partly "tunnel," that is, the marble has been followed under the slate, leaving, as it has been removed, cavern-like spaces. This "tunnel" is quite large. I should estimate its breath at seven or eight hundred feet, depth from one hundred to a hundred and fifty feet, and height twenty-five. The massive roof is supported by massive columns left for that purpose. The open quarry is large and both produce abundance of good stone. From the quarry an inclined tramway leads down to the mill, a mile or so below. The track is double, so that a loaded car in descending, draws up an empty one on the other track. Most of the product of this quarry goes to Philadelphia. Going south along the east side of the mountain we soon reach a large quarry not now worked called the "Blue Ledge." A very pretty bluish marble is found here and the enormous dump heap shows the extent of past working. Still further south is a very promising looking quarry, also unworked, called the Folsom quarry. There appeared to be an abundance of good stone here awaiting the enterprise of some energetic quarryman. Going on to the southwest side of the mountain we find the Edison quarry which produces a finely veined stone in large blocks, but when sawed the sheets are very likely to be unsound. The quarrymen called my attention to a curious phenomenon which has also been observed in one or two quarries at Pittsford and Brandon. As the surface of the marble deposit is cleared, channelling machines are run back and forth across it until the bed, three, four, six feet deep, as it may happen, is cut into long strips, which are then cut across into blocks. In this quarry these strips when cut spring up from the bed below, so that it is difficult to work, as tools are caught and held. One of the northern quarries was abandoned, I was told, because of the trouble this springing caused.

Farther along the west side of the mountain is a large quarry which is just being opened by the Dorset Mountain Marble Company. There is here a slendid mass of marble of quite varied shading. Borings show a bed of marble several hundred feet thick and apparently very sound, but as to this only trial can determine, for even the most expert quarryman is unable to foretell whether blocks that seem perfectly sound as they are taken out, will prove so, when sawn. A few rods north of this new quarry is an older one formerly known as the Prince quarry, but now worked by the company just mentioned. Considerable marble has been taken from this place and it is still worked. One great obstacle which these Dorset Mountain quarries must overcome is their distance from railroads. Except the Freedly quarry, they must all send the rough stone by teams over a difficult mountain road for several miles. It is fortunate that the hauling is all down hill, so that large loads can be drawn. At the base of the mountain, in Dorset, there are several quarries now abandoned. The largest of these, and one which was once very actively worked, is that of Kent & Root. This, with the large mill, not far off, now stands deserted and desolate.

So far as I know, marble was quarried at Dorset before it was obtained in any other locality. Says Professor Seely in "The Marble Border of Western New England," to which I am indebted for numerous valuable suggestions and facts: "The first quarry opened at Dorset was by Isaac Underhill in the year 1785 on land owned by Reuben Bloomer and still held by the Bloomer family. The quarry was first wrought for fire jambs, chimney backs, hearths and lintels for the capacious fireplaces of the day. People came a hundred miles for these beautiful fireplace stones and considerable trade in them soon sprang up. Other quarries were soon in operation and from 1785 to 1841 nine quarries were opened."

North of Dorset there were formerly quarries in North Dorset, Danby and Wallingford, but none of these are now worked. Most famous of Vermont marble beds are those at West Rutland, and the name Rutland marble is used in trade to designate either that from these quarries or from Proctor. In this region there are in all about thirty quarries, most of them worked.

Twenty-five of these are controlled by the Vermont Marble Company, which is said to be the largest in the world. The West Rutland quarries are in two groups. Most of them are on the west side of a north and south ridge, extending about half a mile and the stone from these is mostly quite light in color, while a mile and a half north on the same ridge are two quarries which produce no light marble, but a very fine dark stone. There is here a vast deposit of unusually sound and desirable stone, and on the opposite side of the valley there are other fine deposits not worked. The marble is in beds, or layers, which dip to the east at varying inclinations from 20° to 80°, the average dip being given as about 45° The beds are together from 50 to over 100 feet thick. The quarries here are really great pits. There is a rectangular opening perhaps 200x250 feet, and the walls descend vertically, or nearly so, to a depth of 200 or in some cases 300 feet.

The first or "covered quarry" is 300 feet deep, and there are two tunnels about 200 feet long, running under the cliffs. Blocks of almost any size which can be moved by the hoisting machines can be obtained from these quarries. The marble in some quarries varies but little from layer to layer, while in others there are several varieties in a single layer. Some layers produce pure white statuary, others most daintily veined or clouded, show a white ground variously streaked, blotched or veined with green, in one bed, blue in another, yellow or light brown in another, olive in another, and it is easily seen that the mixtures and relative amount of these veins in the white ground may be innumerable. I do not know how many shades are recognized in trade, but in the State collection there are blocks which represent twenty varieties. It is said that in one of the West Rutland quarries there are "fifteen different layers varying in thickness from two feet to ten, and varying also in color, texture and value."

The following section, taken from the Eighteenth Annual Report of the U. S. Geological Survey, will aid the reader in understanding the structure of these quarries:

Blue marble, top White marble	20	feet
Green striped	2	"
White statuary	5-6	"
Striped monumental	2-6	"
White statuary	3-6	"
Layer partly green, partly white	4	"
Green and white "Brocadillo"	2½-3	"
Crinkly, silicious layer, half light, half dark	2-3	"
Light and mottled	4-6	"
Green striped	6	in.
White	2½	"
Half dark green, half white	3-6	"
Italian blue	15-20	"
Mottled limestone	——	

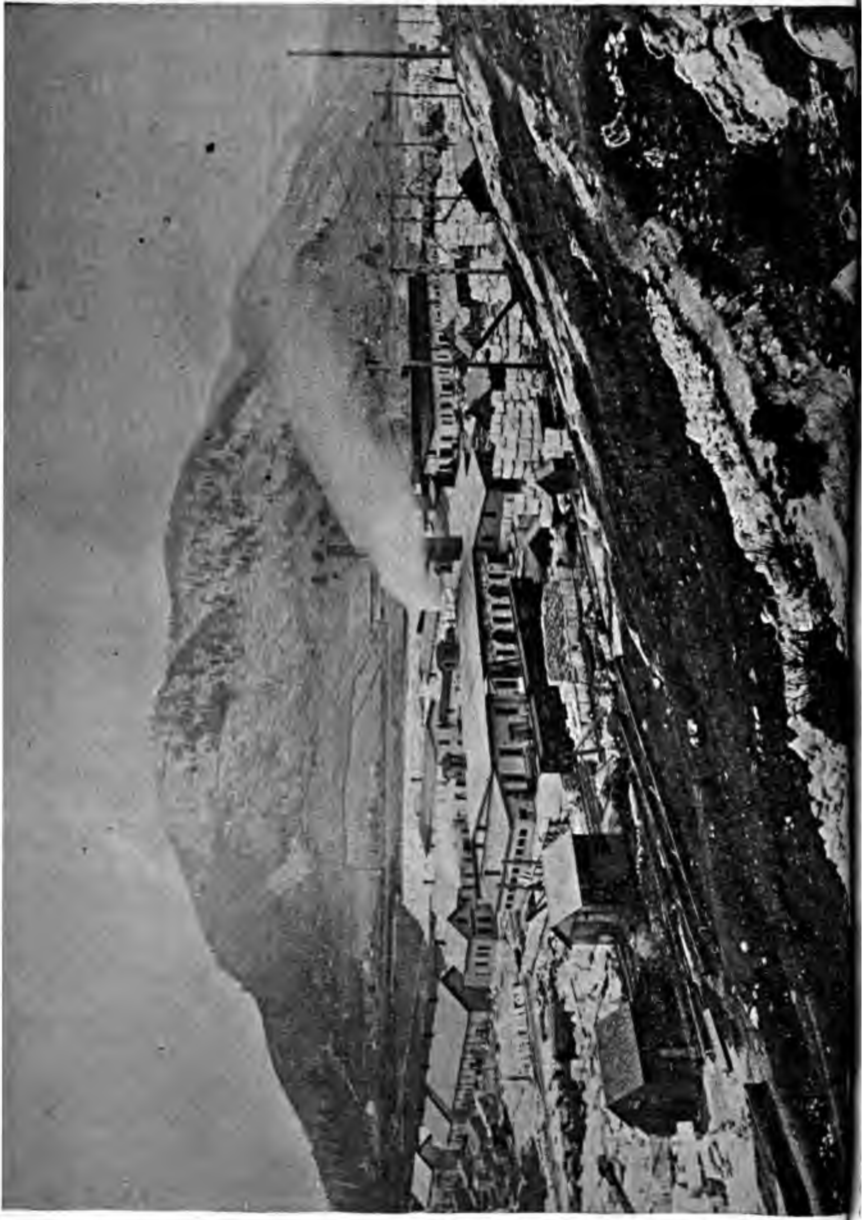


Figure 3. Marble Mills at West Rutland.

Figures 3 and 4 give a good view of some of the narble mills in which the stone is sawed and cut, and

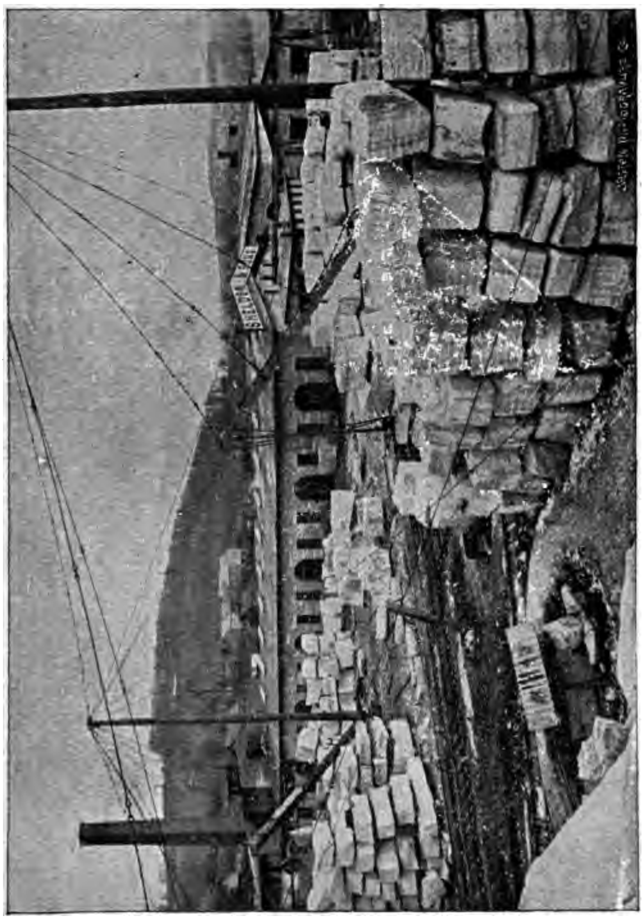


Figure 4. Marble Mill, West Rutland.

igure 5 is a rather poor illustration of some of the quar ies, which I introduce here because, though not as good s could be wished, it gives a better idea than words alone f the character of these quarries. I am indebted to the uttle Company for these illustrations.

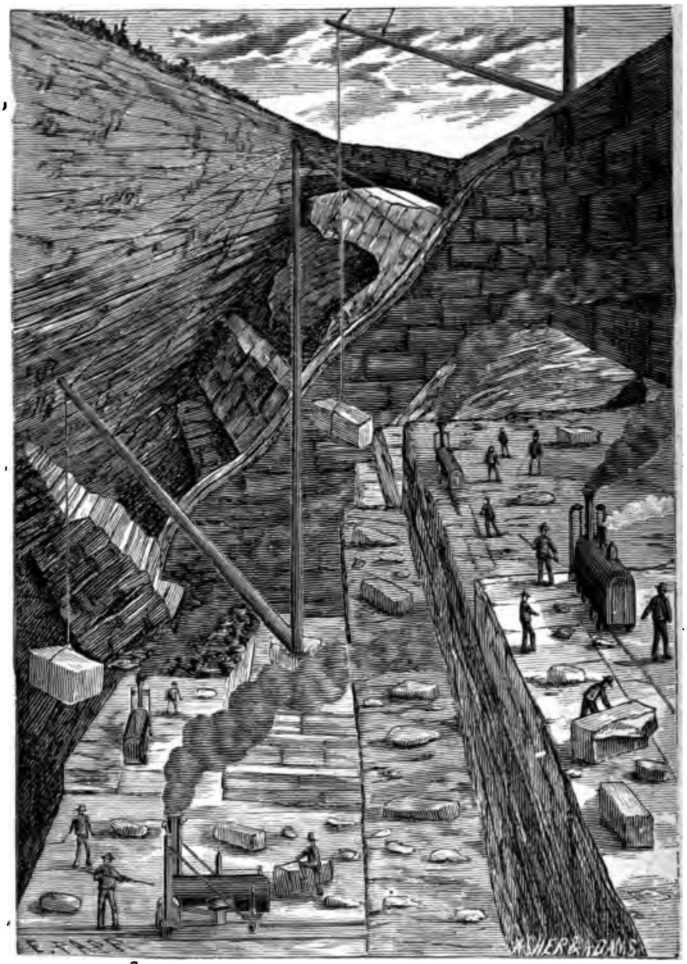


Figure 5. INTERIOR OF QUARRY AT WEST RUTLAND.

The two northern quarries, the Esperanza, worked the Vermont Marble Company, and the True Blue, work by an independent company, are in the same bed of dar richly veined and clouded marble, which is very effecti for interior work. It seems to be a compact, hard, a durable stone.

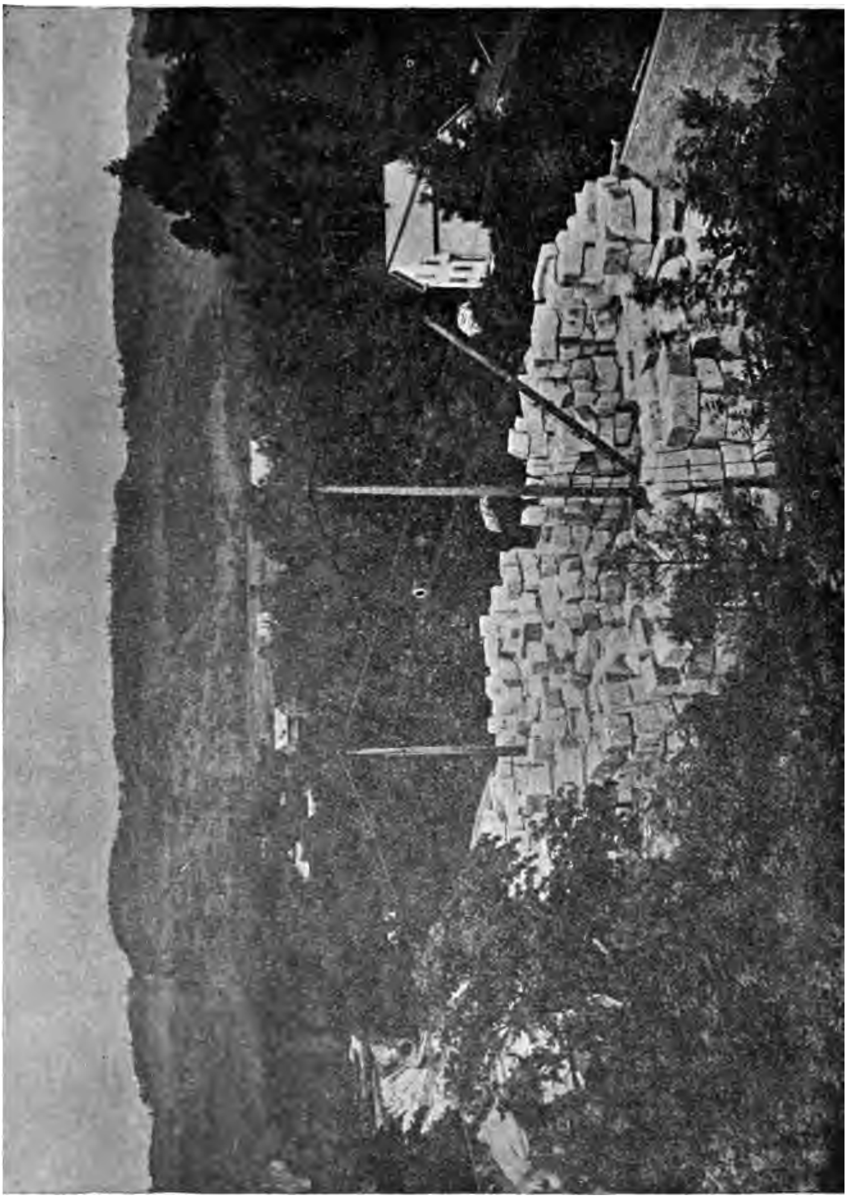
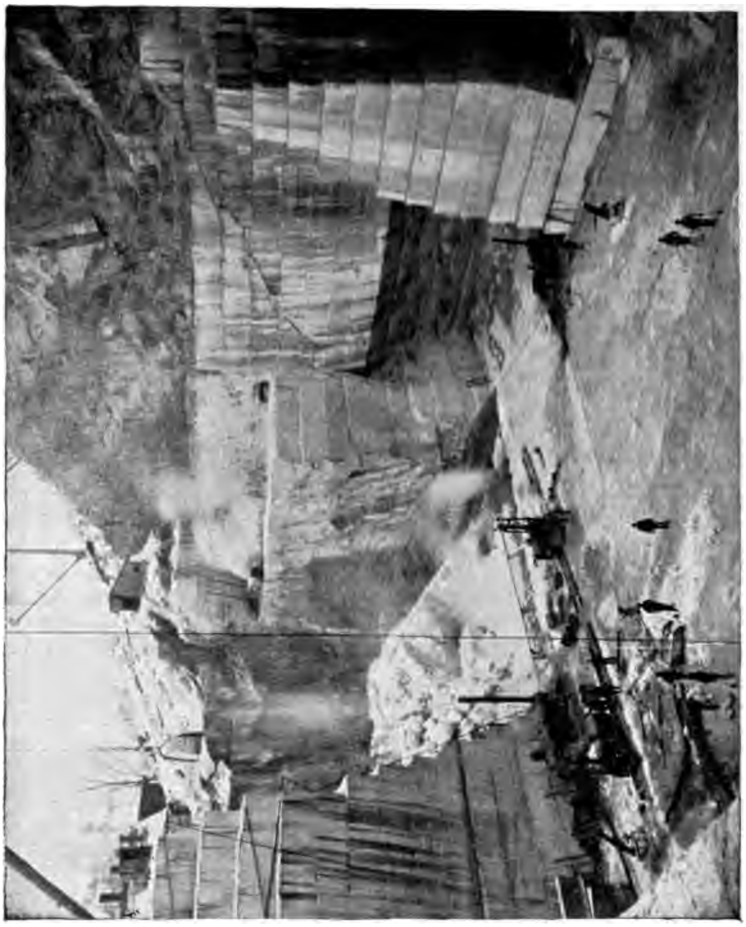


Figure 6. View from the Sutherland Falls Quarry, Proctor.

Going around, or over this ridge, we find on its eastern slope the old Sutherland Falls quarry at Proctor. Figure 6, though not showing the quarry, is taken very near it,



MARBLE QUARRY AT PROCTOR.

Figure 7. SUTHERLAND FALLS QUARRY, PROCTOR.

and shows blocks taken from it. Through the courtesy of Mr. Spear, I am able to give the accompanying illustration of this famous quarry, said to be the largest quarry in the world. Its impressive proportions do not appear in the illustration, which, like all those of quarries, fails to represent the magnitude of the object. This quarry is located in what appears to be a gigantic pocket, or mass of marble enclosed in limestone on all sides. An immense quantity of marble has been taken from it, and at present the walls at the highest point must be 200 feet high, and the area of the floor is three acres. The beds of marble are nearly horizontal, though there is an evident anticlinal arrangement. The marble is mostly rather light, though the dark "mourning vein" is quite dark. These "mourning veins" found in this quarry are very fine. The markings are numerous, almost black, and very wavy. Of this Prof. Seely writes in the "Marble Border": "It would be interesting to know the origin of these mourning marbles, in which the white and black are so curiously mingled. The material giving the black appearance is undoubtedly carbon, and probably in character approaching the graphite, which marks the coarsely crystalline limestone of the Adirondack region. When freely exposed to a high heat the dark color disappears, leaving a white line. A conjecture might be ventured that the rock was originally of different chemical composition in the different parts; in the white the oxidation of the carbon was complete during metamorphism, while in the dark the oxidation was interfered with. A second conjecture would be that during the metamorphism, the particles of carbon moved together and became aggregated, as in the Adirondack marble. The first suggestion is supported by the actual difference in the character of the dark and white portions, the former carrying with it insoluble silicious minerals. A further thought suggests itself, whether the darkly mottted marbles will not be found to be metamorphosed Black River limestone of the New York geologists." I have already noticed that the thickness and extent of the layers in some of the quarries is such that very large blocks can be obtained. Figure 8 shows one of the buildings of Princeton University, built of Sutherland Falls marble. The columns in front of this building are turned from a single block, and they are twenty feet long and three feet in diameter at the base. One of the large groups of statuary on the Boston Post-office is carved from a single block of the same marble. In the falls of Otter Creek at Proctor the Vermont Marble Co. have a convenient and most valuable

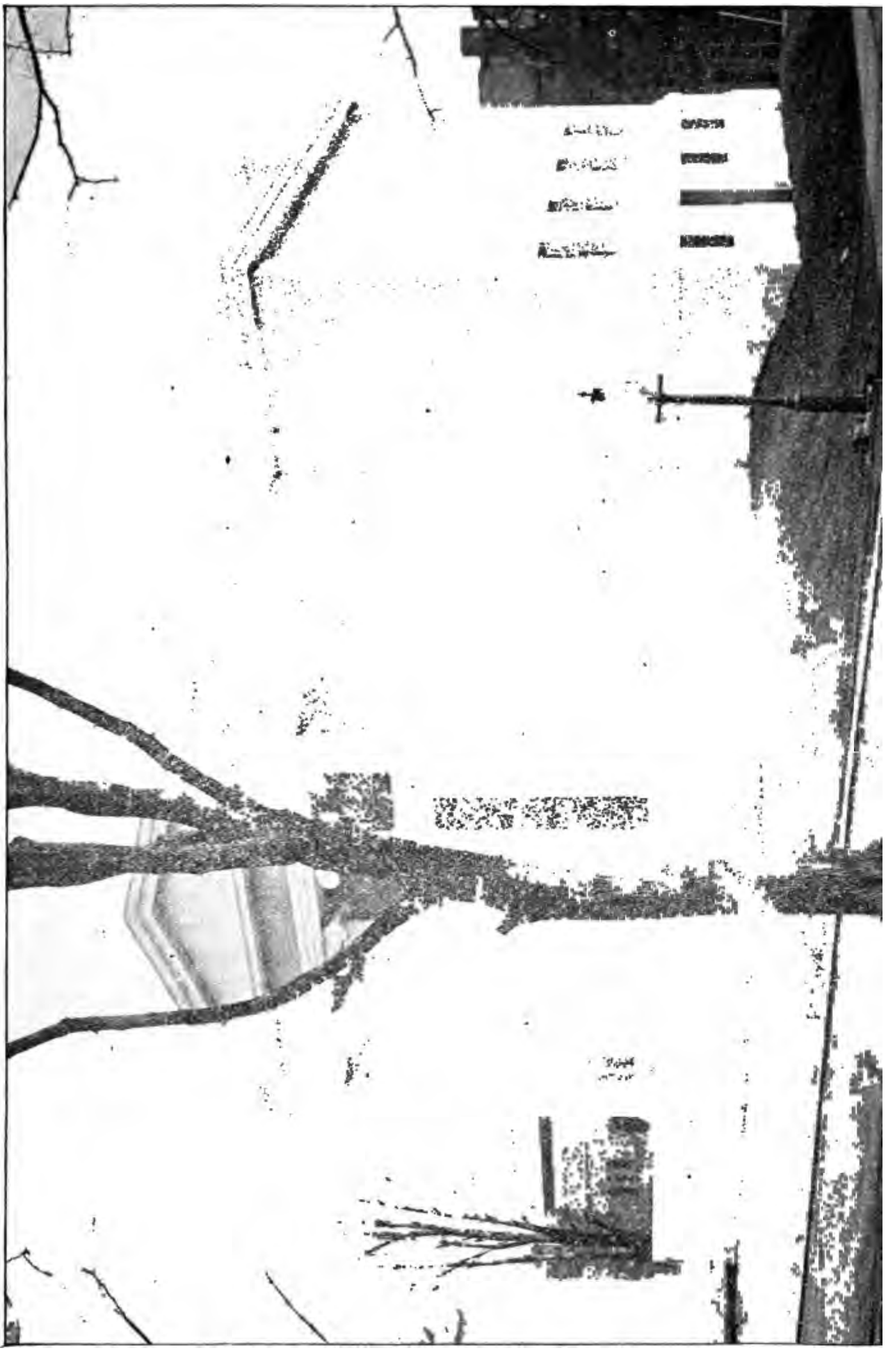


Figure 8. Clio Hall, Princeton University. Built of Sutherland Falls Marble.

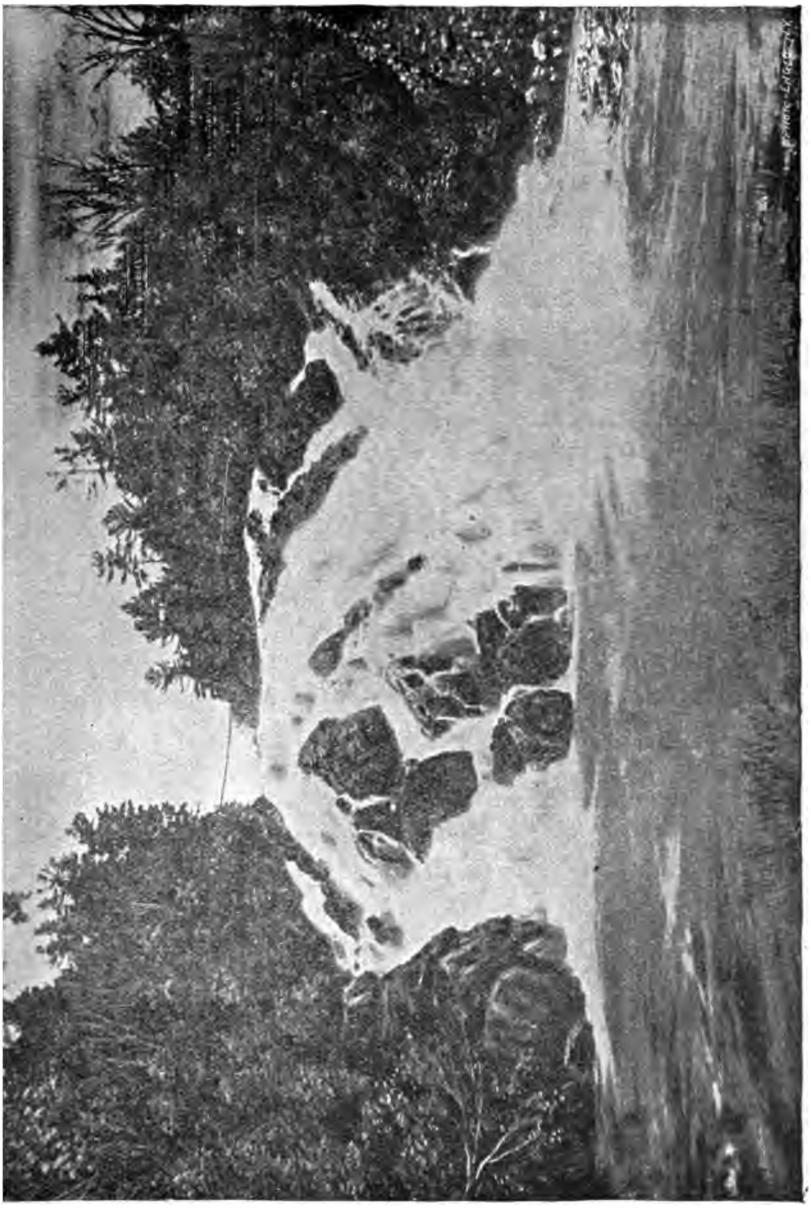


Figure 9. FALLS OF OTTER CREEK, PROCTOR.

source of power by which to run their mills, for it is obviously cheaper to use water power than steam. These falls, which are well shown in the illustration (Figure 9), supply from 2,000 to 2,500 horse power.

North of Proctor, and between that place and Pittsford, are several quarries, not now worked, and one of considerable importance called the "Mountain Dark," which is in operation. As the name indicates, the marble is of dark bluish color. It is, however, troublesome on account of frequent flaws. Very much of the marble quarried is troublesome and unprofitable on this account, and even in the best quarries the waste is considerable. As has been seen, the quality of the marble cannot always be accurately determined by an inspection of the blocks, and therefore it not infrequently happens that an apparently sound block is transported to the mill and sawed into slabs before its real character is ascertained. If then it be poor, there is not only the loss of the stone, but of all the labor which has been expended upon it. Within the limits of the marble region it is not difficult to find abundant marble. The main trouble is to find that which is sound and perfect when worked. Small specimens are of little value as indicating the soundness of larger pieces, and no one should be misled by them. Almost any quarry will furnish a square foot or so of sound marble, though it may never yield any larger pieces. Several miles north of the Mountain Dark quarry, there are several quarries in Pittsford, all producing a dark marble. It is a handsome stone, but quite liable to imperfection, though good blocks are by no means unattainable.

Quarrying was carried on in Pittsford quite early, not so early as at Dorset. The oldest quarry was opened in 1795. According to Professor Seely, in the "Marble Border," there are three beds of marble in Pittsford, extending north and south. "The most easterly of these has a breadth of about 200 feet, and on it was opened, in 1871, the quarry known as the Central Vermont quarry.

It was successful until the great depression of 1874, from which it has not yet rallied. The marble is of the same character as that at Proctor, of which bed it is probably a continuation. The middle bed is separated from this easterly one by about 200 feet of lime rock. This bed is itself 400 feet wide and contains marble of different shades, from pure white to a dark blue. Buildings made of this marble have stood the test of years. * * * The third or west bed, thought to correspond to that of West Rutland, is about half a mile west of the Central and abuts on the west against the slate, this having disappeared from all the region east of it. This bed, about 400 feet wide, holds beautiful dark blue marble, mottled and veined." In this last named bed there are two considerable quarries, the Hendee, worked by the Vt. Marble Company, and the Florentine, the stone from which is sawed at Beldens Falls.

North of Pittsford I found no quarries in operation until reaching Brandon, where there are at present two, besides several not worked. I was told that the Corona quarry, still farther north, was also worked.

About two and a half miles southwest of Brandon station is the Bardillo quarry and mill. Here there is a peculiarly elegant stone, quite unlike any other that I have seen. The very numerous, strongly-marked, narrow veins which traverse the blocks in sinuous or zigzag lines, in quite unique fashion, and yet with a certain regularity, make this a very handsome stone. It varies in shade from light to dark gray. The quarry is not large, but the supply seemed to be good and the beds were thick and solid. The quarry was opened, the workmen tell me, in 1882. Most of the product is worked up on the spot into monuments. A much older quarry is that known as Brandon Italian, which is nearer town, being about half a mile below the station. The Bardillo quarry is located on a hillside, and the stone is quarried, thus far without going to any great depth. This other quarry is much deeper, and is peculiarly long and narrow. The beds are thick; at the time of my visit the channeling machine was cutting out a bed 6 ft. 8 in. in thickness. The mill which had been operated at the quarry burned last winter and the company are building a new one at Middlebury, to which place the blocks will hereafter be taken to be worked up. This marble is solid, and light colored, that is, white with dark veins.

There were formerly several quarries in Middlebury, but none are now worked. I have spoken of the loss which always attends marble quarrying, because of the unsoundness of much that is obtained. Throughout the marble belt good marble is never found near the surface. Hence, when a quarry is opened in a ledge, a greater or less, but always considerable, mass of waste stone, earth, etc., must be removed. For this reason every one who undertakes to open a quarry must spend a considerable sum before he can begin to look for returns. This is well stated in a pamphlet published by the Vermont Marble Company: "A marble deposit being found, it is first bored, and with a machine constructed for the purpose, a solid core is taken out, from which the quality of the marble is easily determined. The soundness, however, can only be proved by opening; and the opening of a marble quarry, unlike granite, is a laborious and expensive operation. From forty to seventy-five thousand dollars has been spent upon several of the West Rutland openings before stock that would even pay to saw has been taken out. The quarry being stripped of the top rock, channeling machines, driven by power, are put on and the entire quarry floor cut into strips, a cut being also made at each end. Small holes at intervals of a few inches are then bored into the bottom of the layer, by means of machines constructed for that purpose, and called gadding machines, and into these holes are driven iron wedges. In this way all of the layer that has been cut is freed from its bed, and it is not unusual to see a strip of rock 50 ft. or more in length raised in this manner. The layer is then in the same way broken into blocks of the size desired, and the marble is hoisted from the quarry to the bank by huge derricks, and if of suitable quality, sent to the mill to be sawed."

Many interesting questions arise as to the origin, age, etc., of the marbles of the region we have been considering. Only very briefly can these be discussed here. As to the origin of these marbles, not of all those kinds of stones sold under the name, but of the marbles in the Rutland district, geologists are agreed that they are metamorphosed limestone. That is, that the ordinary dark, fossiliferous strata, such as we now find at Larrabees Point or on Isle la Motte, has been, in the marble region, softened, heated, compressed, crystalized until transformed into the non-fossiliferous, light colored marble. As to the age of these marbles, we may speak with confidence, because of the investigations of a Vermont geologist, who is almost unknown in his own State, the Rev. A. Wing of Whiting, who died about 20 years ago. Mr. Wing, by dint of most careful study of the marbles and ledges of Rutland County, established their age beyond doubt as of the Chazy limestone, one of the lower members of the Ordovician or Lower Silurian. That is, the marble is of the same age as the limestones of the southern portion of Isle la Motte, at Fisk's and Fleury's quarries. Although most of the beds, as those at West Rutland, are of this age, it may be that some are older, and some, as Prof. Seely has suggested, are newer. Chemically, limestone and marble do not very widely differ. Lime carbonate is the chief component of each, but there are some important differences. In the 18th Annual Report of the United States Geological Survey, several analyses of Rutland marble are given. A single example must suffice for the present:

	BLUE MARBLE.	WHITE MARBLE.
Silicate of Alumina	.22	.62
Carbon dioxide	44.00	43.80
Lime	55.15	54.95
Magnesia	.57	.59

The above shows that there is little difference between the dark and light varieties, in the substances which compose them. In the same Report we find the following:

"Vermont is likely to remain in the first place for the production of fine marble for many years to come, in spite of claims of superior product which are occasionally made in connection with new discoveries elsewhere;" and also the statement that the "marble of West Rutland and its vicinity is as yet without a peer in the United States for the finest uses to which marble is applied, and it supplies a large proportion (elsewhere stated as 81 per cent) of the stock used for cemetery work."

Aside from the great quarries and mills with their hundreds of workmen and vast output which have been mentioned, there are in Vermont other quarries which produce marbles of which we may well be proud. The marble quarried on Dorset Mountain has much of it been taken to Manchester to be worked, hence outside of the State it is often called Manchester marble. There is no quarry of true marble in Manchester, but there is a quarry of breccia, which was sold as marble, but which is no longer worked because of its unsoundness. It is a very interesting and handsome stone, quite unlike any other in the State. It is composed of fragments, of different sizes, of red, gray, white or brown stone, cemented together by a dark red material. Were it only sound it would be a very attractive stone for interior work.

What are known as the *Champlain Marbles* are quite unlike any found elsewhere in the United States. They differ materially from the true marbles in that they are not metamorphic, but are substantially as originally deposited. They belong to an older period geologically than the white marbles and are much harder.

All are highly colored and all take a most brilliant polish. The prevailing colors are white and various shades of red, from dark red-brown to delicate flesh color. Olives and light greens are also sometimes seen in certain layers. They belong to a geological formation known as the red sandrock, which is, in age, middle cambrian. This formation extends from Canada through northern Vermont south as far as Shoreham. It is not of great extent from east to west, but forms a narrow band near the shore of Lake Champlain and approximately parallel with it. Many of the head-lands on the eastern side of the lake are of this rock. Most commonly it is a hard, dark red sandstone containing besides large percentage of silica, eight or nine per cent of potash, about the same of iron, and more or less of lime. The composition of the rock is not uniform, but differs greatly in different portions even of the same stratum.

The color, though chiefly dark red, is sometimes light red or even reddish-buff. Moreover the entire formation, which is about two thousand feet thick, includes limestones, dolomites, slates and shales, though the red sandrock is, in most places, by far the most conspicuous member of the formation, and forms the greater part of its thickness. Still, in some localities other beds make up a not inconsiderable portion of the whole, as the following section taken at Swanton by Sir William Logan, and given here with some modification, shows:

	Feet.
1. White and red dolomites (Winooski marble) with sandy layers; —some of the strata are mottled, rose red and white, and a few are brick red or Indian red. Some of the red beds contain *Ptychopariá adamsi* and *P. vulcanus*	370
2. Gray argillaceous limestone, partly magnesian, holding a great abundance of *Palæophycus incipiens*	110
3. Buff sandy dolomite	40
4. Dark gray and bluish-black slate, partially magnesian, with thin bands of sandy dolomite. The slate contains fossils as *Kutorgina cingulata*, *Orthisina festinata*, *Camerella antiquata*, *Ptychopariá teucer*, *Olenellus thompsoni*, *Mesonacis vermontana*	130
5. Bands of Bluish mottled dolomite, mixed with patches of gray pure limestone and gray dolomite and bands of gray micaceous flagstone with fucoids	60

A mile or so north of the above section, other strata occur as follows:

6. Light gray more or less dolomitic sandstones and "some of which are fine grained, others are fine conglomerate." These are interstratified with bands of white sandstone. 630
7. Bluish thin bedded argillaceous flagstones and slates, containing *Conocephalites arenosus* and fucoids 60
8. Bluish and yellowish mottled dolomite 120
9. Yellowish and yellowish-gray sandy dolomite 600

Still further north, on the Canada line, there are additional strata, though not well exposed, but in general Sir William gives them as follows:

10. Buff and whitish sandy dolomite, holding a great amount of black and gray chert in irregular fragments of various sizes up to a foot in length and six inches wide. There are also masses of white quartz. Thickness (conjectured) 790

Most of the layers are not fossiliferous, and in few are fossils abundant. It may be true that fossils are really more common than they seem to be, for they only occur as casts, and, with the exception of the Algæ, these are rarely visible except when the surface of the stone has weathered so as to leave them in relief, and of course this happens only occasionally. Near Burlington, where the stone is extensively quarried for building purposes, some of the layers exhibit abundant casts of Algæ, together with mud cracks, ripple marks and other evidences of shallow water formation. Farther north, at Georgia, and still more to the north, at Highgate, various trilobites and Mollusca have been found of the genera Oleuellus, Ptychoparia, Camerella, Orthisina, Obolella, etc. (see No. 4 above). The dolomitic portion of the beds constitute what has long been known as the "Champlain" marble.

The beds of "marble" appear first one or two miles north of Burlington and extend in a somewhat interrupted series north, through St. Albans and end at Swanton. Some of the layers are quite distinct from the red sandrock proper, others pass into it by imperceptible gradations. Ordinarily the marble beds are far less siliceous an the main bulk of the sandstone, often containing nly one-seventh as much silica as that usually contains, even less, but they are always much harder than ordiary marble. Analyses of the marble have been made, ut cannot be of great value when applied to the whole ass, because the relative proportion of the substances omposing it is extremely variable.

Identical results would scarcely be obtained from anlyses of any two specimens taken at places a little distant rom each other. Silica is always present, usually about en per cent, lime carbonate forms from thirty to orty per cent, and magnesia carbonate about the same, hile iron and alumina form a smaller portion of the nass.

No fossils had been discovered in this portion of the ormation until a few years ago, when looking over a pile f sawn fragments—refuse from the mill at Swanton—I oticed two or three pieces which contained evident fossils. hese were afterwards identified by Mr. Billings of the Caadian Geological Survey, as *Salterella pulchella*, described y him from the Straits of Belle Isle, and not hitherto known om Vermont. It is only with difficulty that this fossil n be detected in uncut pieces of marble, but when blocks hich contain specimens of it are sawn they are quite oticeable, as they are pure white and imbeded in the red one, appear as small thimble-shaped, oval, conical or rcular bodies, as they are cut in one or another direcon. It seems probable that the *Salterella* occurs roughout the dolomitic beds, for I have found it at their xtreme limits near Burlington and Swanton. The fossil , however, not common anywhere. It occurs in patches ometimes as large as one's hand, scattered over the slabs ere and there. Other fossils also occur in marble, but re not so well defined as to be certainly identified.

More than thirty years ago the beauty of the mottled olomite attracted the attention of marble workers, and a uarry was opened about six miles from Burlington, and some of the blocks of stone taken out were sent to New York and Philadelphia to be sawn into slabs and polished. The results were, I believe, satisfactory in every way except financially. The stone made beautiful slabs for table tops and mantels, but its hardness, while adding to the beauty of the polish which it received, rendered the sawing and finishing so costly that after a short time the attempt to place it in the market was abandoned.

Quarries were also opened, many years ago, near Swanton, and these are still operated by the Barney Marble Company. The Swanton quarries are about a mile and a half southeast of the village, on the east bank of the Mississquoi river. The deposit here is extensive and forms a considerable ridge extending along the river, from the west side of which the stone is quarried very conveniently. The layers dip some 20 to 30 degrees to the southeast. The quarries are mainly surface quarries, and thus far the excavation has nowhere been very deep. The beds are of good thickness and very fine. Sawed blocks can be readily obtained. I measured some of these blocks that were lying near the derrick at the time of my visit. One was 9 ft. x 4 ft. x 4 ft; another 12 ft. long and less regular in form. Most of the blocks were of the common size found at all the quarries, viz.: 6 ft. or 8 ft. long and 4 ft. x 4 ft. at the ends. Blocks 16 feet long have been quarried and worked up. Indeed, the capacity of the derricks and the possibility of handling large blocks is all that determines the size of those quarried. All of the stone must be hauled by teams to the mill at Swanton, where the fine water power afforded by the falls in the Mississquoi, is well utilized by the company.

This marble has been used in many public buildings in different portions of the country, notably in some of the corridors at the capitol at Albany, as wainscoting, and also in the new wing of the Astor library in New York. It should be noticed here that while this marble is unrivaled for inside work it is not well adapted to situations in which t is exposed to the weather, as its colors fade and its eauty is greatly impaired when thus exposed. There eems to be great inequality in this respect in blocks from ifferent layers. At least this is indicated in the appearnce of blocks that have been for some years lying about he quarries. Some of these appear to be but very litle changed, while others have their surfaces reduced o a nearly uniform yellowish-red. No one need fear any hange in the appearance of polished slabs when protected rom the inclemency of the weather.

Perhaps the most remarkable characteristic of the Champlain marbles is the wonderful variety of shade and general appearance which they present.

Not only may slabs which are quite unlike each other be obtained from a block as it is sawn parallel with the stratification or transverse to it, any variation in the direction of the saws giving variety in the slabs; but even the opposite surfaces of the same slab may differ greatly. The rock in some of the layers is a more or less complete breccia, white or light-colored fragments being enclosed in a dark red paste. These fragments are of all sizes, from those several inches long and wide to those no larger than the head of a pin. In some cases several adjacent bits were, when first held in the paste, one large piece, and subsequently broken, as the fractured edges of each exactly correspond to those of the pieces next it. The brecciated structure is conspicuously perfect in some blocks and quite imperfect in others, and it finally passes into what was evidently a pasty mass of nearly uniform fineness before consolidation took place. Some of the beds appear to have been much more thoroughly worked over, and the materials more completely ground and mixed than others, and the different varieties are in part due to this.

While but few colors are seen in the different layers, nevertheless these are mingled in such varying proportions as to produce unlimited diversity. Shades of red are especially abundant, so that almost every conceivable tint is found; less common are green, chiefly in olive shades, drab and rarely yellow, all mingled more or less abundantly with white, The different specimeus may conveniently, though without absolute exactness, be arranged in several series. One of these would embrace those slabs in which the red, which in most cases is the predominating color, is clear and decided. In this series we have many varieties, from those in which the red is like that of jasper, or what is known as Indian red, to those in which it is simply a delicate pink, like the lining of a shell. Another series gives us the red always of a brownish or chocolate cast, and this is sometimes very dark. This in turn passes through all intermediate shades to almost white. In a third series the red shades are less conspicuous, and with them are mingled greens and greenish-drabs or sometimes lavender shades. It is easy to understand how endless variation may be produced by varying combinations of these different shades with white. This is true both in the blotched and in the shaded layers. Those which show the brecciated structure more or less clearly vary as the fragments are large or small, and whether many large are mingled with many small or the reverse, and whether many large light fragments are mixed with dark small ones, or large dark bits with small light ones, and in the clouded or shaded layers light bands and blotches may predominate in one slab and dark bands in another. It will be obvious that no description of such marbles can convey to those who have not seen them very clear ideas of their appearance. More than thirty varieties of this marble have been named by one company or another, but most of these are not used. There are six, more commonly placed upon the market by the Barney Company, though, of course, others can be supplied if desired.

The Mallett's Bay beds of this marble, alluded to on a previous page, have been repeatedly worked, and some fifteen years ago a company called the Wakefield Marble

Company invested considerable capital in quarrying, erection of mills, and placing the marble on the market. They were obliged to use steam power, which was one reason of the failure of the undertaking. The hardness of the stone and consequent slow progress which saws and other tools make in working it, render the relative cost of steam and water power very unequal. Although this enterpise, so thoroughly begun, has not been successful, I cannot believe that the great beds of beautifully colored marble which exist at Mallett's Bay are never to yield profit.

Messrs. Fisk & Bradley have this year opened a new quarry in the same formation as that in which the Barney quarries are located. A great variety of colors is found here and the outlook is very promising.

There are large beds of a light drab limestone in and about Swanton and extending south to St. Albans, which is extensively quarried and burned to make lime by Messrs. J. P. Rich at Swanton and W. B. Fonda at Swanton Junction, large quantities of lime being produced by these gentlemen. But in addition to this use of the stone, large blocks are quarried, which are taken to the mill and sawed, to be finished as "Swanton Dove" marble. The delicate drab of the general mass of the stone is varied by veins of pure white, thus producing one of the neatest marbles in the market.

Perhaps the most elegant marble which is quarried and finished in Vermont is also produced by the Barney Company. It is a very fine verde antique, most superbly veined in various shades of green, with veins and blotches of black and also of pure white. It is very hard, being a serpentine, and receives a very high polish. For many sorts of interior work nothing can be more effective than this verde antique, but it is difficult to work, and for that reason is more expensive than any other kind. The quarry from which this stone is obtained is at Roxbury. It was worked many years ago and some large pieces taken out, and then for years it lay deserted, until a short time ago the Barney Company took it in hand, and have since done considerable work in getting out the stone. As now opened, the quarry is not a large one. It is located on the east side of a considerable hill, about half a mile south of the station, near the railroad. So far as developed, the the bed of marble, or serpentine, is 12 to 16 feet thick, but the bottom has not yet been reached. Immediately above the marble is about 20 feet of greenish schist. At the north end is a bed of white talc. Green talc, actinolite and asbestus are also found in the quarry. Some large blocks have been gotten out. I saw at the mill blocks 9 feet long and three feet square at the ends. Some of these are very dark, others quite light.

In the town of Washington a dark bluish siliceous limestone is quarried which, when finished, is very handsome. It is peculiar in shading, and in those blocks which are abundantly intersected by darker veins is of very striking appearance. Dr. F. A. Warner has not only opened a quarry, but built a mill in the village, where the stone is cut and polished. At the time of my visit, there were some beautiful specimens of the marble in various monuments, slabs, etc., at this mill. I am greatly indebted to Dr. C. F. Richardson, instructor of geology at Dartmouth College, for the following notes concerning this marble and the region in which it occurs. Dr. Richardson has repeatedly and carefully studied the part of the state referred to in his notes, and they are especially interesting because very little trustworthy information respecting the geology of eastern Vermont is to be had: "The Washington limestone is, in general, a dark gray, siliceous rock. The coloring matter is uncombined carbon. In the southern and western portions the limestone is darker and contains many beds of plumbaginous mica schist. The deposits at Wait's River closely resembles the Columbian arble of West Rutland, which is of the same age. The ternation of light and dark bands of highly crumpled rata, together with the beautiful polish which the rock ceives, makes it eminently suitable for ornamental work.

At Washington more than twenty quarries have been pened since the discovery of the marble five years ago. lies horizontally in sheets from ten to one hundred feet length. Throughout the entire town the formation exeeds 5,000 feet in depth. The rock hammers white, and he polished letters stand out in such bold relief that it is egible at a greater distance than the inscription upon any ranite." The contrast between hammered and polished urfaces is greater than in any stone I have ever seen. hemical analysis of the stone gives most remarkable esults. It seems like a general mixture of all the reagents n a laboratory.

Dr. Richardson sends in the following analysis of two pecimens of this marble:

	Sample A.	Sample B.
Silica, SiO_2	35.748	35.748
Titanic Oxide, TiO_2	.190	.189
Carbon Dioxide, CO_2	22.860	22.870
Ferric Oxide, Fe_2O_3	.010	.010
Alumina, Al_2O_3	6.113	6.112
Ferrous Oxide, FeO	.940	.941
Glucinum Oxide, GlO	.818	.815
Manganic Oxide, MnO	.076	.075
Baric Oxide, BaO	.210	.210
Calcic Oxide, CaO	27.305	27.304
Magnesic Oxide, MgO	8.248	8.244
Sodic Oxide, No_2O	.186	.187
Potassic Oxide, K_2O	.063	.064
Lithic Oxide, L_2O	.823	.824
Water, H_2O	.108	.107
Phosphorous Pentoxide, P_2O_5	1.359	1.359
Chlorine, Cl	.307	.307
Fluorine, Fl	.026	.026
Carbon, microscopic trace	....	....
	99.885	99.892
Less O_3 Cl. & F	.079	.079
	99.806	99.813

The Washington limestone, like the marble at West Rutland, was undoubtedly once regularly stratified, fossiliferous rock, but it has been to a certain extent metamorphosed and the fossils obliterated. Dr. Hitchcock has found fossils in rock of the same formation at Derby and Dr. Richardson in the marble at Wait's River. Dr. Richardson writes: "The most abundant palæontalogical evidence is in the Canadian territory at Willard's Mills, Castle Brook, Magog, Quebec, where many species of graphtolites occur in great abundance. The slates in which they occur are lithologically homogeneous with the roofing slates of Montpelier and Northfield. These slates, the Bradford schist with its patches of limestone and the Washington limestone with its peculiar beds of biotite and plumbaginous mica schist, are lower Silurian, and, more specifically, lower Trenton." These observations are very interesting and important, because the rocks involved cover a larger area than any formation in the State. They are found over much of that portion which lies between the Green Mountains and the Connecticut River.

On Isle la Motte there are extensive beds of limestone, some of the layers of which have been used as marble. Some of this is black, some gray, the latter mottled on account of the presence of numerous small fossils or fragments of large ones. One of the oldest quarries in the State is the Fisk quarry, on the southwest side of the island. It is said to have been opened before the Revolution. It is near the shore of the lake where there is a dock, to which a tramway runs from the quarry. The accompanying illustration, furnished by courtesy of *The Vermonter* (Figure 10), gives a fair idea of this quarry.

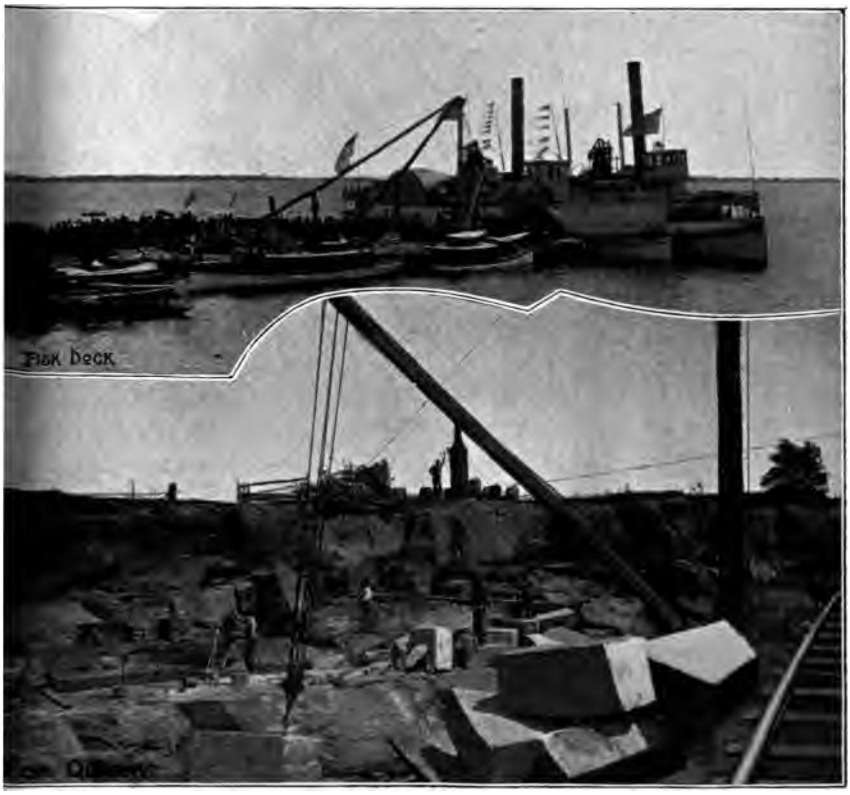


Figure 10. Fisk's Dock and Quarry, Chazy Limestone, Isle La Motte.

An immense quantity of stone has been removed from this quarry, for, although the walls are not high, I should think nowhere over 20 feet, yet the upper layers have been removed over an area of six or seven acres, if not more. The strata of Chazy limestone are nearly horizontal, the dip being only a few degrees to the northwest. The stone is black, or very dark, compact and solid, and has been, as it still is, in demand for bridge piers and foundations. The large black blocks from some of the layers when sawed make a good black marble, which is known in trade as Fisk black. There are also gray beds which produce a marble called "French Gray." This stone was largely used in the piers of the great Victoria bridge. Some of the beds are two feet thick, others six, eight or ten. In this quarry fossils are not abundant. Most conspicuous are masses of stromatocerium. Maclurea magna is also not infrequent, and orthocerata and other fossils now and then occur. The stone is evidently a deep, still-water deposit, which has been to some extent uplifted, but not otherwise much disturbed. A short distance southeast of Fisk's quarry is another large one known as Fleury's. This is a lighter colored stone, most of it being gray. The strata are not as thick and are more fossiliferous than those at Fisk's, and are somewhat older. They belong to the older layers of the Chazy limestone, and are near the Calciferous. The layers contain numerous brachiopods as orthis, strophomena, camerella, trilobites as asaphus, cheirurus, and illænus and some corals. There is also a dock and tramway here for loading the stone. The strata are somewhat more disturbed than at Fisk's, but the dip is not very great. The whole southern end of Isle la Motte is made up of lower and middle Chazy, in many places wholly uncovered or only partly covered by a thin layer of glacial drift. Over these nearly level or only slightly dipping strata, one may drive for a mile or two north to Goodsell's quarry, on the eastern shore of the island. The beds here have been worked deeper, so that the bottom of the quarry is considerably below the general surface, while at Fisk's or Fleury's one may drive directly from the road into the quarries and over the floor, especially at Fisk's. The rock at Goodsell's quarry is gray, with maclurea and stomatocerium, and apparently is middle Chazy. A thorough study of the geology of Isle la Motte would be to a geologist a most interesting task, for it is a region which affords many attractive localities, which invite investigation. In a paper published by the American Museum of Natural History, Bulletin, Vol. VIII., p. 305, President Brainerd and Professor Seely have given a brief account of their investigations on the Island. They found that the total thickness of the Chazy was 634 feet.

At the southern end there is a little Calciferous rock, and in the center are Trenton beds.

THE SLATE INDUSTRY.

More than fifty years ago a writer spoke of Vermont as "justly celebrated for its roofing slate," but at that time there were apparently few quarries and a not large production, and yet even then, 1845, some quarries had been worked forty years. In those early days an important part of the business of a slate mill was the manufacture of the now obsolete school slate, and, from softer layers of slate pencils.

The great slate region of Vermont is in Rutland County, but slate has been obtained in Northfield and Montpelier, and in Benson in considerable quantity, but is now quarried only to a small extent.

In the slate belt of Rutland County there are over sixty concerns engaged in the slate business. All of these do not own or work quarries, but some operate several, so that it is within bounds to state that between fifty and sixty quarries are, or recently have been, worked in this one county. It is not easy always to ascertain the precise number of quarries in any given vein, for the term is not always used with the same meaning. The best definition of a slate quarry was given me in the office of Messrs. Norton Bros. at Granville. It seems that the common lease of a slate quarry includes a strip of land twenty rods wide. Therefore, originally a slate quarry must be a part of the ledge of this width, and perhaps of the same or less length, the width being reckoned along the slate ridge. By some of the men, each pit was called a quarry and this might do very well were it not for the fact that in course of years of quarrying several adjacent pits are no longer separated, but, the wall of stone between having been removed, they are continuous. Others consider each derrick a quarry and count the quarries by derricks.

However we may choose to reckon the quarries, no one can visit the region from Hydeville through Poultney to Pawlet without being convinced that they are very numerous.

This slate belt begins with the Lake Bomoseen quarry at Cedar Mountain, six miles north of Fair Haven, and extends southward through Poultney and South Poultney to Pawlet, a distance of about twenty-five miles. Contiguous to the Vermont region is that of Washington County, New York, and the whole is geologically one. Most of the offices of the quarries at Pawlet are in Granville, N. Y., and several of the companies operate quarries in both Vermont and New York.

A few of the quarries are located on the side of a hill and are more or less surface quarries, but most are rec-

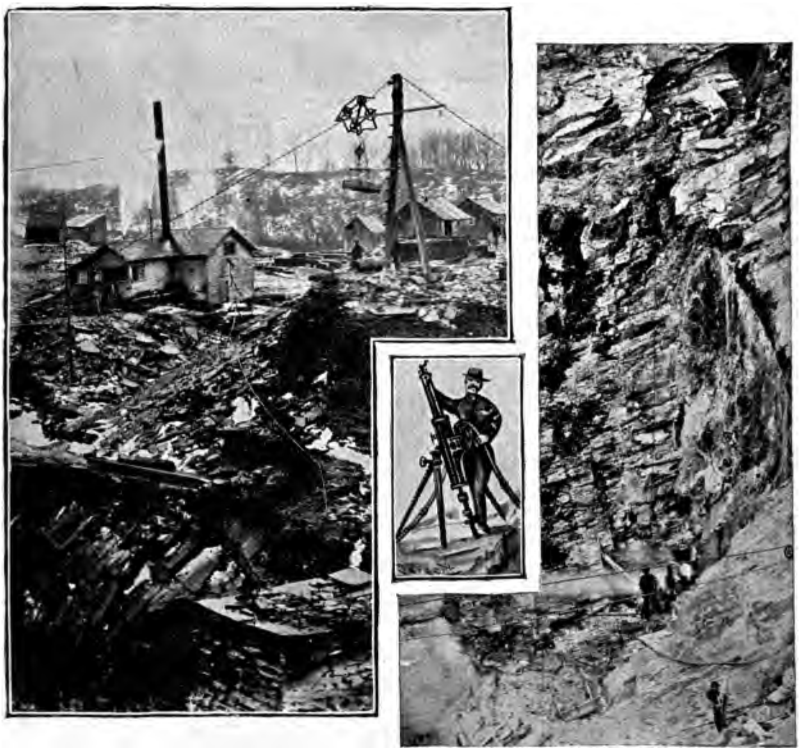


Figure 11. **Slate Quarries.**

angular pits. The quarry is begun on top of a ridge and he slate followed down at a high angle, or even perpenicular, for one, two, or three hundred feet, the average epth being no far from 150 feet. On account of this

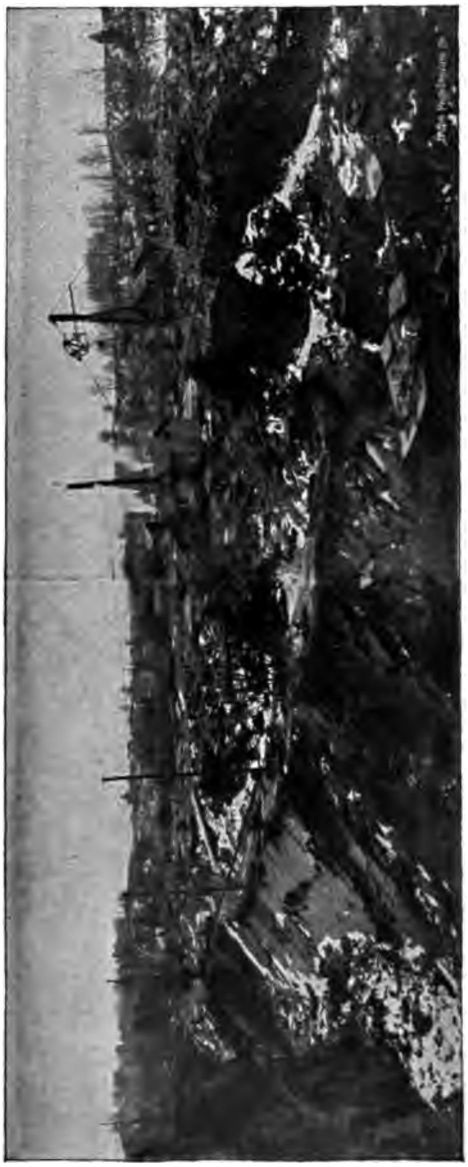


Figure 12. Slate Quarries.

character, good views of slate quarries are not easily obtained and I am unable to show any that are satisfactory.

The accompanying illustrations, figure 11, loaned by Hon. V. I. Spear, Secretary of the State Board of Agriculture, is about as good as any. This, with the other illustration, figure 12, which shows one of the larger quarries at South Poultney, which The Tuttle Company furnished, will help one to some idea of the appearance of the slate region, about the quarries.

The most northern quarry is the Lake Bomoseen, six miles north of Fair Haven. It is very near the shore of the lake and large pieces of slate can be loaded on boats and thus be transported to the railroad or mills at Hydeville. This quarry, which produces a fine purple slate, is a surface quarry, the slate being taken from the side hill. The quarry is at some distance from any that are now worked, but formerly there were extensive quarries and millsat West Castleton, a mile or so southwest, but they became unprofitable, and what was a scene of busy activity is abandoned and desolate. Still farther west and south there are several quarries now worked with good promise of increasing business. Between these quarries and Hydeville is a locality known as Scotch Hill. Here there are two quarries of fine purple slate. At the Humphrey quarries, or rather at the mills, I saw the finest large slabs that I found anywhere. This firm produces only large pieces, or what is called "mill stock." The adjacent quarry, owned and worked by Mr. J. Williams is peculiar in that its product is not worked up at all, but is sent in the rough to mills at Hydeville. The beds here are very thick and of excellent quality. After leaving Scotch Hill we find no more quarries until we are beyond Hydeville. Here are several large quarries, beginning with that of the Blue Slate Company. Here some roofing slate, but much more "mill stock" is produced. Beyond this quarry is a series of large ones extending through

"Hyde's Patch" towards Poultney. One of these, the Eureka, is said to be the largest in the State. North of Scotch Hill, there was a quarry known as the Old Harvey, in which were beds of what is known as "Unfading Green" slate, and at the Eureka we find the same in greater quantity. This seems to be really a green slate which keeps its color, for in the piles of waste I could see no difference between fragments that had lain a long time exposed to sun and storm and those which had only lately been thrown out. This Unfading Green is in great demand in England, and I was told at several quarries where it is found, that half of what they produce is exported. The Eureka quarry produces from 1500 to 1800 squares of roofing slate a month, Besides the green, purple and variegated slate is obtained at this quarry. Quite similar to the Eureka are two large quarries, one on each side of the road to Poultney. These are the Lloyds, and beyond this, quarry follows quarry until we reach Poultney, or near it, and then there are no more until we reach South Poultney, where there is a group of nine or ten large and long worked quarries. In these, while the slate is mostly of the variety known as "sea green," a light green, but not unfading, there is also much purple and variegated, and in one quarry, Griffith & Nathanaels, there is a bed of very dark gray, called in trade "Poultney gray," which resembles the Maine black slate. At the Auld & Conger quarry at this place, several of the original pits have been worked into one, very long, narrow and deep. A few miles south of these is the largest group of all, I should think, called, from a switch and side track from the Delaware & Hudson Railroad to the quarries, the "Switch quarries." Here the quarries follow each other along the ridge for about two miles. All are very near the New York line, and I believe that most of the offices of the various companies are in Granville, N. Y. All of these quarries produce only roofing slate, mostly of the sea green variety, there being very little purple found in any and none at all in most. There are, I judged, about twenty quarries in operation in this group. The last quarry in the group is, as are all the Switch quarries, in the town of Pawlet. This is the Rising & Nelson. It is on top of a considerable elevation, and is the deepest quarry which I saw. The workmen said that its depth was 300 feet. The slate here is all sea green, and the vast dump heaps indicate long working, and it is probably one of the oldest of the quarries. I was obliged to make a much more hasty examination of all these quarries than was at all desirable. I visited over thirty which were being worked, but many important ones were passed by. The Hughes and Norton Brothers quarries are large and interesting and substantially like those just described. During the last few years the market for most kinds of slate has been dull and prices low, partly, if not wholly, because the great quarries of Pennsylvania, added to those of Vermont and New York, overstocked the market and thus checked the demand. No other state except Pennsylvania produces nearly so much slate as Vermont, but that state far exceeds us. Of late, however, the business is reviving and the demand increasing. All of the slate producers of whom I inquired agreed that their business was decidedly improving. This is also shown by the opening of new quarries and the investing of new capital.

It is interesting to note the difference in the color of the slate in different quarries, or rather in different parts of the slate belt. This has been noticed incidentally already, but a review of the whole region will make the fact more evident. At the quarry on Lake Bomoseen, at Cedar Mountain, there is little else than the purple, which occurs there in fine beds, though there is some green. South from here, just beyond West Castleton, both purple and unfading green are found. Still further south, at Scotch Hill, only purple, and although unfading green and variegated, that is, purple more or less blotched with red, occur in considerable beds at Hydeville and Hyde's Patch, purple is very abundant, and so on to South Poultney, when the sea green becomes more abundant, and little purple occurs in most of the quarries, and there is the bed of "Poultney gray" mentioned above, which occurs only in one quarry. Beyond South Poultney, in the great group of "Switch quarries," the slate is almost wholly sea green. It may be noticed that the unfading green and the sea green, though very similar in color and appearance, differ in texture and chemical composition, one, as the name rightly indicates, enduring exposure without change, the other fading if much exposed. The fine red slate which is in constant demand for roofing and which therefore brings a much higher price than other colors, is found only in Washington County, N. Y. It is exceedingly tantalizing to an ardent Vermonter to ride through the slate belt and be constantly forced to notice how invariable the red beds are on the New York side of the line. For a dozen miles or so beds of red slate occur on the New York side, in full view of one standing in Vermont, and time and again reaching almost into our State, but never coming quite across the border. It would seem highly probable, since this is all one slate region, that at any time beds of red slate may be found on our side of the line, but thus far all search for them has been in vain. In all the quarries it is necessary to remove not only the glacial drifts which covers the whole country, but the upper layers of slate are of no value, and it is sometimes necessary to take off 20 to 50 feet of these top layers. The blocks of rough slate are removed from the beds, so far as possible, by wedges and bars. Blasting is, of course, at times necessary, but is resorted to only as a necessity. The blocks when detached are hoisted and placed on cars, or wherever they are to be further reduced, by very ingenious and specially adapted apparatus, worked by steam power. The blocks are often large and maybe very irregular. The beds in different quarries seemed to me to vary considerably in the manner in which they could be broken. Some broke into quite regular masses, others only in very irregular fashion. If roofing slate is to be manufactured the large blocks are broken into smaller, until those approximatin the size of the slate wanted are obtained. Various size are used, but in most of the quarries I found that slate 10x20 inches were most in demand, especially abroad. A skilled workman takes one of the blocks and very deftly using a wide chisel and mallet, splits it first into severa thick slabs and then each of these into the thin slabs which, when trimmed in a machine with a large revolvin knife, become roofing slate. When, instead of this, "mil stock" is wanted, the process is, naturally, quite different In this case larger blocks are quarried and with corresponding care. These are hoisted and placed upon the bed of sawing machine, where they are cut into regular form. I necessary, the surfaces are planed or otherwise smoothe The manufacture of slabs for billiard tables, stair tread platforms, and the like, seems to be limited to compa atively few quarries, and chiefly those in northern part o the slate belt. Some, as that at Cedar Mountain and thos on Scotch Hill, produce no roofing slate; others, as th Blue Slate Company, produce both roofing slate and mil stock, while the series of large quarries at South Poultne and Pawlet produce almost wholly the roofing slate.

At present the annual production of slate in Vermon amounts to about $850,000 and from 1,400 to 1,500 me are employed. Most of the workmen in the slate quarrie are Welsh, and some of the owners are also Welshmen.

Slate has been obtained at Benson, but I was not abl to visit that locality, and can make no report concernin it.

The only slate quarry which is now worked in th eastern part of the state is at Northfield. In years gone b a considerable amount of good slate has been obtained fro this place, and I see no reason why profitable quarries ma not be operated here, though before expressing any de cided opinion I should wish to examine the ledge muc more carefully than I have thus far been able to do. Fo merly there were four or five quarries, but only one is no in working order. This is about two miles southeast of the village, and is being vigorously worked by the Dole-Brill Slate Co. Unlike the quarries of Rutland County, this produces sound stone almost to the surface, so that the waste is very little. The slate, like all that of Northfield, is of excellent quality—strong, unfading, and of a fine dark color like the black Maine slate. The color is not like that of any of the slates of Rutland county except the Poultney gray of Griffith & Nathanaels, to which it is similar, though darker. There seems to be an unlimited supply of this slate in the ledges about Northfield. As we have seen, this slate is lower Silurian in age, as are those of Rutland county most probably.

THE GRANITE INDUSTRY.

It is but few years since Vermont had any reputation as a granite-producing state, although the existence of extensive granite ledges has been well known ever since the state was settled. In the first Report on the Geology of Vermont, which was published in 1845, granite is only incidentally mentioned and not a single quarry is particularly noticed, though there were then a few of no great importance. Probably the largest quarries were then, as now, at Barre, for the State House was built in 1837 from Barre granite, and this was probably very much the largest contract taken by a granite quarry in Vermont until perhaps ten years ago, when, after slowly increasing for many years, the granite business, chiefly at Barre but not wholly, suddenly increased to unexpected proportions.

In 1880 Vermont produced, according to the Census Report, 187,140 cubic feet of granite, which was valued at $59,675. In 1889 the production was 1,073,586 cubic feet, valued at $895,516, and in 1897, according to statistics collected by my predecessor, Mr. G. W. Perry, the granite produced by 87 companies was valued at $1,512,543. In 1880 Vermont ranked thirteenth among granite-producing states; in 1890 our state had advanced to the ninth pla in 1896 to the third, only Massachusetts and Maine p ducing more, and in that year the latter state did not p duce nearly as much as Vermont did last year, and Mas chusetts but about 6 per cent. more. As I have no reas to think that the output of granite has increased these two states as it has done in our own, I think it s to assume that at present Vermont is at least second in t amount of this stone sent out, and that if she is not alrea first, she very soon will be, for there are no signs that c granite industry is abating its progress and developme but, on the contrary, new quarries are being opened and c ones more actively worked than ever. If the above is tr Vermont now leads the country in marble and granite, a is second only to Pennsylvania in slate.

Granite beds are more widely scattered over the st than those of either marble or slate. Marble especiall limited to a few comparatively restricted areas. Nea all of the slate, too, is obtained from the quarries of Fa haven, Poultney and Pawlet, though the Northfield d posits are considerable, and there are smaller patches other places. The great beds of granite are at Barre a Woodbury, and these I think are parts of the same vast c posit and no such deposit is to be found elsewhere in t state, if anywhere in the country. Hence these beds w always be the most important. Smaller deposits, howev exist, and most of them have been worked at one time another.

These are found at Beebe Plain, Derby, West Co cord, Greensboro, Chelsea, Groton, Ryegate, Williamstow Northfield, Bethel, Sodom, Victory, Kirby, Morgan, N ton Mills, Dummerston, and perhaps elsewhere, and syenite at Windsor. I do not mean that granite is n quarried in all these towns, for that is not the case, but exists in all, and has been at one time or other quarried all. So far as I can ascertain, there are about seventy fir in the state concerned with either quarrying or manufacturing granite, many do both.

All of our quarries are open, and most, or many, surface quarries. An exposed ledge is attacked and the stone removed. Unlike marble and slate, the granite is not unsound near the surface, though better at a considerable depth below it. Hence there is little or no waste surface material to be removed at greater or less expense. This, as well as the nature of the quarries, makes quarrying much cheaper in the granite region than it is in either the marble or slate belts. I regret that the time which I could take for inspecting the granite quarries was so short that I cannot hope to do them justice. Many I could not even look at, much less examine with the care they deserve. Again I must refer to a future report for a more adequate treatment of this most important interest. For the present, as in the rest of the Report, I can only do so much as has been practicable under the peculiar circumstances of my appointment. I visited such quarries, I have introduced illustrations as could most readily be found.

Granite is a composite of three common minerals—quartz, which is much the same as flint, feldspar and mica, or isinglass. The quartz is usually transparent or glass-like or it may be white, the feldspar is usually a dull white, the mica is generally black. The color, or rather shade, of granite is due chiefly to the relative amount of mica present. The very light or nearly white granite, like Barre white, of which only a small amount is obtained, is light because the mica is much of it light colored. Light granite of trade is a light gray, the mica not being specially prominent in the mixture, though abundant. More dark mica makes a medium, and much a dark or very dark, if the black scales are unusually abundant. This is true of Vermont granites which are all gray. I do not know of any red granite in the state.

As to its origin, granite is probably much of it of volcanic or igneous formation. That is, it is molten matter which has surged up from below the surface in great volume and cooled, crystallizing during the process. Geologists are more and more numerously inclining to the opinion that a large part of the granites are formed in this way. Other granite, which can not be distinguished from that of igneous origin, is formed from sedimentary rocks by metamorphism in a manner somewhat similar to that already noticed in the discussion of the origin of the Rutland marbles. I think that we have good reason to believe that our Vermont granites, or at any rate those of Barre and Woodbury, were formed of this last mentioned process, and that these granites are transformed lower Silurian, with perhaps some Cambrian strata. That is, the limestones and sandstones of these periods have been heated, softened, squeezed and crystallized into the granites, just as these same strata have, by a variation in the process, become the schists and gneiss of the Green Mountains and eastern Vermont.

It seems probable that both granite and marble will be used in increasing quantities as building stones. Granite, as has been mentioned, is quarried more economically and the rough stone is therefore cheaper than marble. Its greater hardness, however, makes it more difficult to work, and therefore more expensive in the finished, sawed and polished monument or column than is the softer marble. This latter stone is said to be coming into use more and more extensively for monuments in the South, where the milder climate does not affect it, but in the more severe Northern climate granite stands the test better, and is becoming increasingly popular for the construction of large and costly monuments and mausoleums.

Moreover, the bright, clear color and enduring quality of the Vermont granite are bringing it into favor as never before. In several very rigid and thorough comparative tests which have been made recently, Vermont granite has proved superior to any other tested. Perhaps the increase of the granite industry in Vermont is best shown by the facts in regard to the growth of Barre, for there is no reason to suppose that this, for a Vermont town, phenomenal progress, is due to anything else than the development of the granite quarries and the money which this has brought to the town. In 1880 the population of Barre was 2,060, and the property valuation was about $700,000. In 1890 the population had increased to 6,790 and the property valuation was $3,500,000. The population is now estimated at not less than 10,000, and the value of property is considerably larger than in 1890, and the past year has been one of unusual prosperity.

For facts regarding the granite works at Barre I am indebted to quite a number of residents of that place, but especially to the *Barre Enterprise* and to Mr. W. C. Olds. The latter has been at considerable trouble to look up statistics. He considers the present value of the annual output in these quarries to be not less than $1,000,000, taken as it leaves the quarry, unworked. Just how many quarries there are at Graniteville and the neighborhood, four miles east of Barre, I cannot ascertain, but there must be between fifty and sixty. About 100 derricks are in use, and 2,000 men, mostly Scotchmen, with a few Italians, are employed in the quarries and finishing shops, or "stone sheds," as they are locally called.

I have already spoken of the fitness of Barre granite for use either as a building stone or for the most costly monument. That this fact is appreciated all over the country is well shown by the following facts. This granite was used in the construction of the Grant monument in Lincoln Park, Chicago. Many of the finest soldiers' monuments have been made of Barre granite: Of the same material are made the Leland Stanford mausoleum at Palo Alto, which cost $100,000; the Goodrich monument in Rose Hill Cemetery, Chicago, costing $85,000; the great crucifix, said to be the largest ever made, at the entrance to Pine Hill Cemetery, Buffalo. These, and the list might be indefinitely extended, are constant witnesses to the beauty and excellence of the Vermont granite.

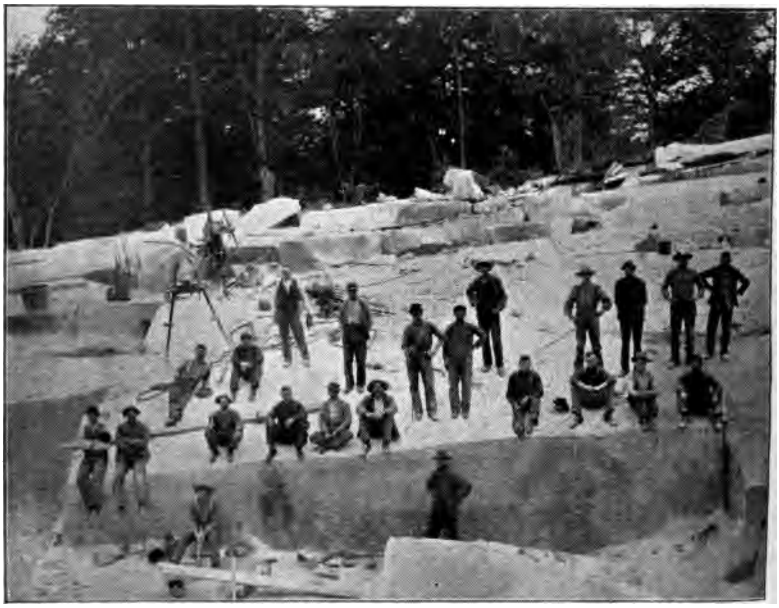
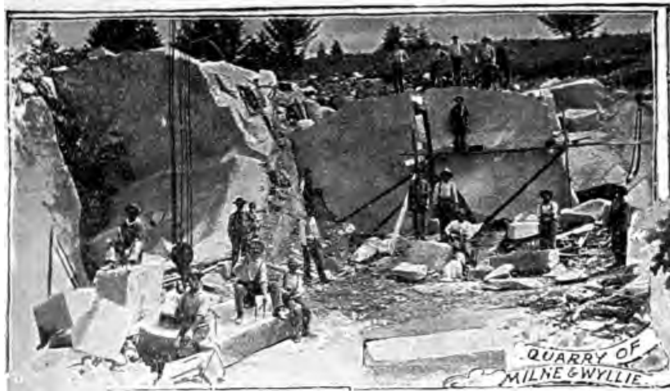
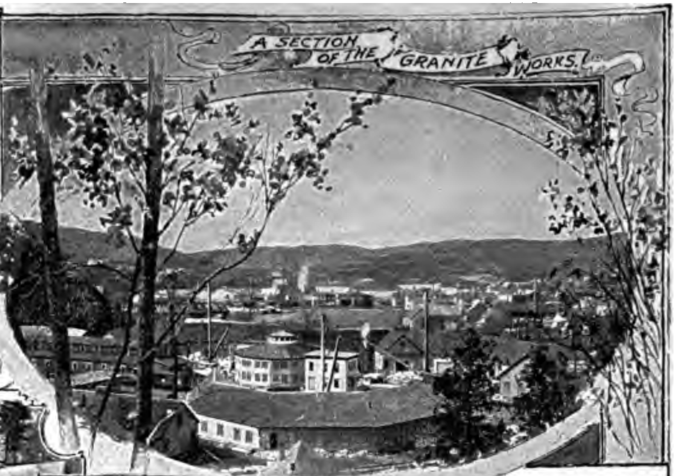


Figure 13. SURFACE QUARRY, E. L. TAYNTOR & CO., BARRE.

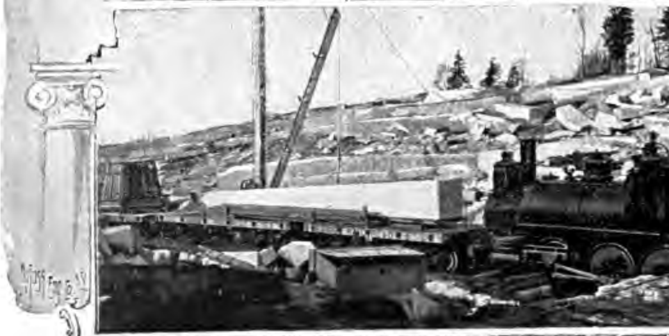
Granite has long been quarried in this region. According to an article in the illustrated edition of the *Enterprise*, one Robert Parker, a revolutionary soldier, first opened a quarry, but not until 1875, when Barre was connected by a branch line with the Central Vermont Railroad, was any extensive work done. So far as I am aware, the first building of importance to be constructed of Barre granite was the State House, built in 1837. The stone for this was delivered in Montpelier for twenty cents a cubic foot, while to-day the same sells at the quarry for from seventy-five cents to $1.00 a foot. From a few tons annually, the amount produced has grown, as we have seen, to large proportions. A single firm shipped in 1896 10,000 tons, and 1,000 tons have been sent over the road from the quarries to Barre in a single day and 100,000 tons in a year. It is stated that if all the buildings and yards used in and about Barre for cutting and polishing granite were combined they would cover fifty acres. The actual terri-



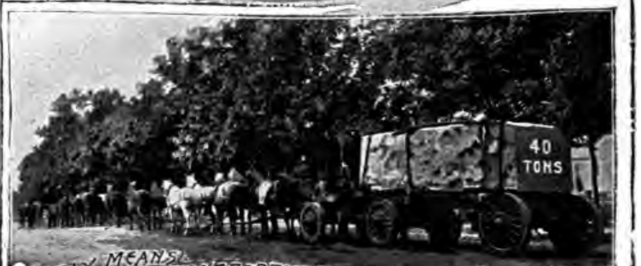
QUARRY OF MILNE & WYLLIE.



A SECTION OF THE GRANITE WORKS.



WETMORE AND MORSE GRANITE COMPANY.



EARLY MEANS OF TRANSPORTATION.

tory in which the quarries are located is not large. M Olds writes: "The quarries are all within a radius of le than a mile, and certainly not more than five per cent. the area within this radius is quarry land." The acco panying views of granite quarries will aid the reader understanding the conditions of the region and its quarrie

Figure 14, which was loaned by Hon. V. I. Spea secretary of the Board of Agriculture, shows very w two of the quarries, a large block on the truck, a meth of transportation still in use to a considerable extent, f notwithstanding the existence of a railroad from Barre the quarries, built by some of the granite companies at cost of $240,000, a great many tons are drawn by team In the upper right hand corner of this figure is a very go illustration of some of the "stone sheds" in which t rough granite is cut, carved or polished. Figure 15 sho one of the larger surface quarries. For this I am indebt to the Montpelier *Watchman*.

Many quarries are like this, others are deeper, thou none go down very far. One of these large quarries said to be sixty-five rods long and sixteen rods in avera width, and covers eight acres. Figures 16 and 17 sho two of the quarries of E. L. Smith & Co., by whom t blocks were loaned.

Figure 16 shows unusually well what is also sho in the quarry of Milne & Wylie in figure 14, namel the very thick bed of stone found in some of the quarri Figure 17 shows one of the quarries of C. E. Tayntor Co., by whom the block was loaned. There seems be no limit to the size of blocks which may be quarri from these beds, except the capacity ofthe derricks, a some of these are of great size. Figure 18 shows a ste derrick in one of the Tayntor quarries, which is sa to be one of the largest ever made. It is ninety-ni feet high, with a boom that has a sweep of sevent seven feet. It is rated at sixty tons, but the owne claim that it will raise more than this. A mile of wi

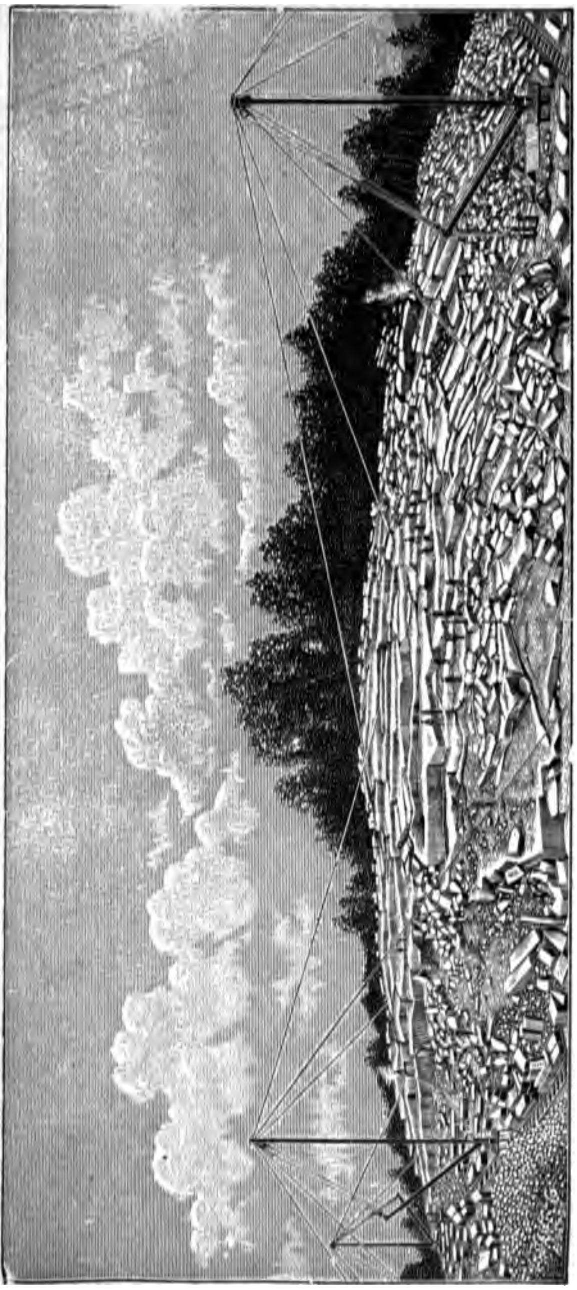


Figure 25. A Large Granite Quarry. Wholly a Surface Quarry

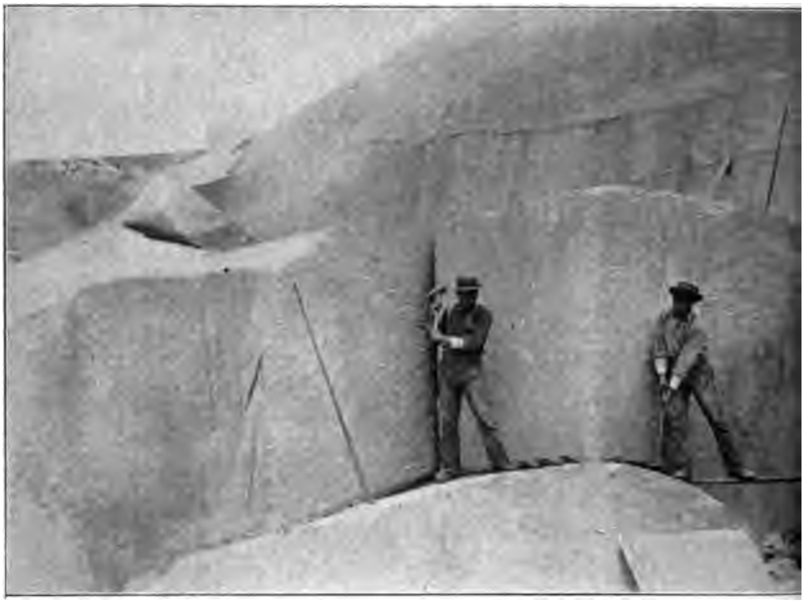


Figure 16. Thickbedded Quarry. E. L. Smith & Co., Barre.

rope is used in connection with this great derrick. There are others of nearly equal size in other quarries. With the aid of these and other appliances for moving great masses of stone and special cars for their transportation to distant cities some very large blocks have been sent out. One of the pieces in the Leland Stanford mausoleum weighed, when finished, fifty tons. The block from which the crucifix mentioned above was carved weighed, in the rough, 160 tons. Another monument, though not all in one block, weighed 210 tons. The largest single piece which had ever been quarried at Barre before this season is shown in Figure 19.

This was from the Tayntor quarry, and was, in the rough, 51 feet x 4 feet x feet, and weighed 150,000 pounds. It was worked into a shaft which is now in Greenwood. Another block nearly as large was quarried by Barclay Brothers, and is shown in Figure 20. This was 46 feet x

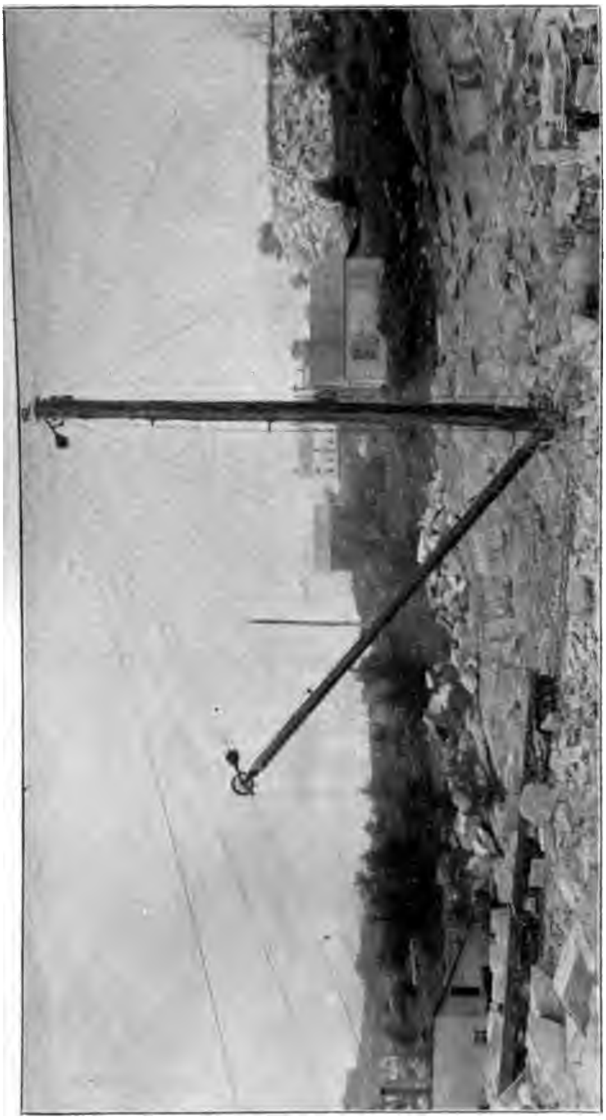


Figure 17. Dark Granite Quarry, E. L. Smith, Barre.

feet x 4 feet. Figure 21 showed a single block which eighed forty-six tons.

A shaft larger than any mentioned was quarried this ummer by Wetmore & Morse Co.

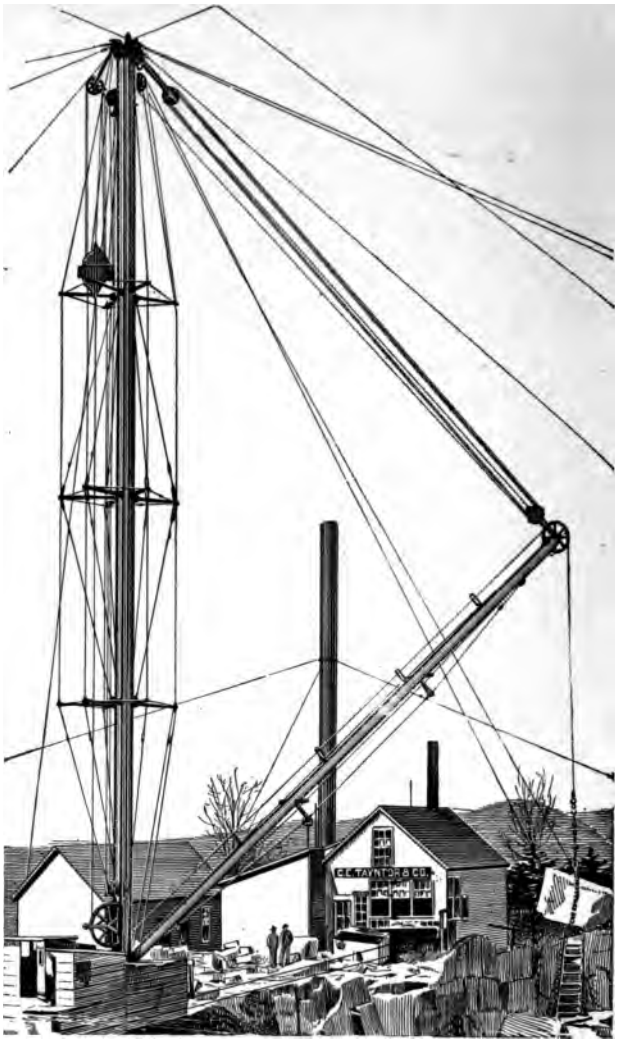

C.E. TAYNTOR & CO.

Figure 18. Steel Derrick, Tayntor & Co., Barre.

About twenty miles north of the Barre granite be are those of Woodbury. The beds here form a sm mountain, and are, therefore, enormous in quantity. Mc of the works where the stone is cut and polished are Hardwick, six miles west, or between Hardwick a Woodbury. On this account the stone is often call

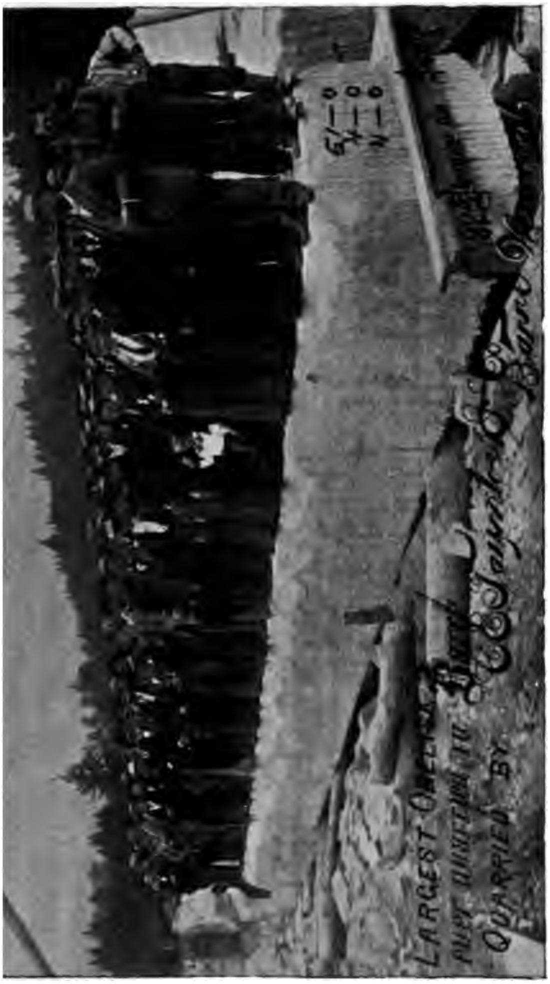


Figure 19. Block Weighing 150,000 lbs., Quarried by Tayntor & Co., Barre.

granite. I was able to visit only two of the ries in operation, and these I examined less than I wished to do. I am indebted to Mr. E. her for facts concerning this granite region. rries here were opened only ten years ago, and the industry is not yet greatly developed. re at present 220 men employed in the six and probably a much larger number in the

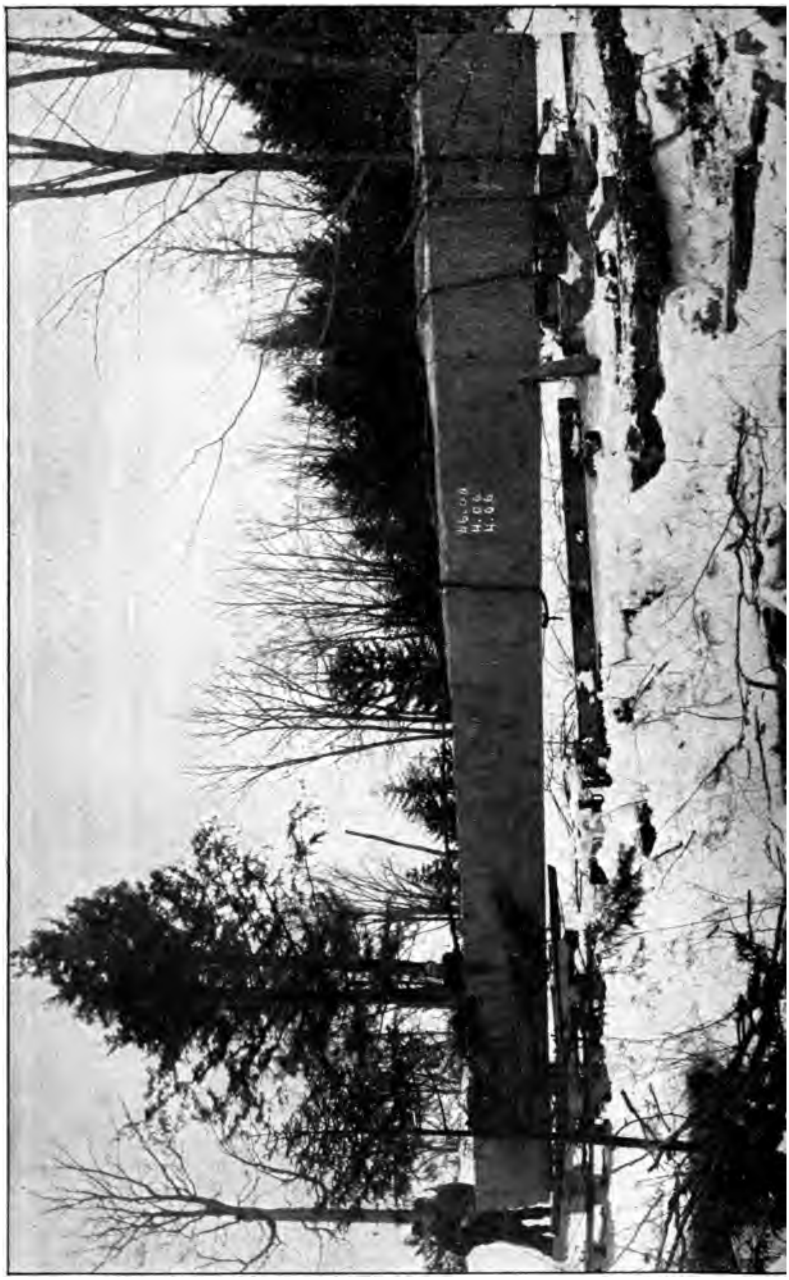


Figure 20. Shaft Forty-six Feet long Quarried by Barclay Brothers, Barre.

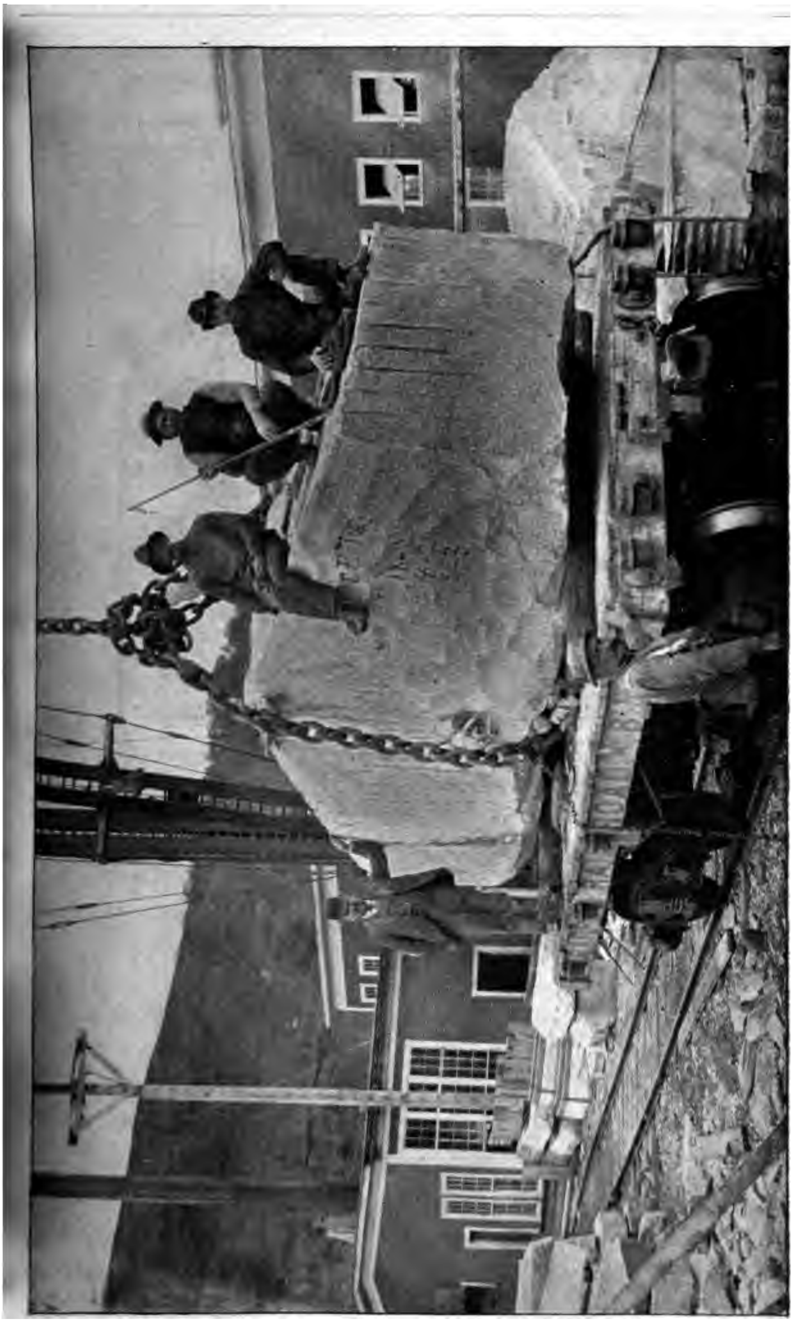


Figure 21. Forty-six Ton Block, Barre Granite.

"stone sheds." About $300,000 worth of granite wil produced the present year. The stone lies in great sh in the Fletcher quarry, and the layers are nearly horiz tal and are very easily removed, and the blocks are rai by derricks, which swing them around on to cars stand on a track which runs by the quarry, for a railroad been built from below Hardwick, where it reaches track of the Portland & Ogdensburg to and among sc of the quarries.

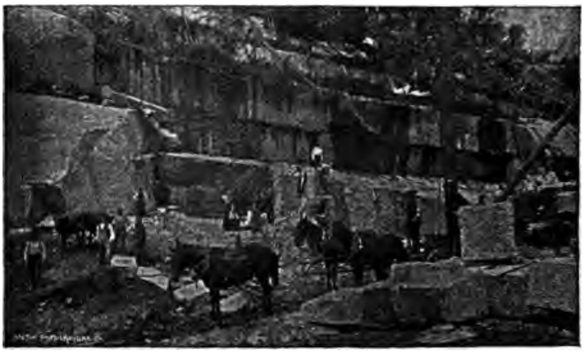


Figure 22. QUARRY OF THE WOODBURY GRANITE COMPANY, WOODBURY.

At the foot of the mountain and below the Fletc quarry, which is near the top, is the quarry of the Wo bury Granite Company, a small illustration of whic given in Figure 22. I could not make any comparat tests, but I could not see much difference between t granite and that at Barre, and, as I have already timated, I regard these beds as of the same general ma The Hardwick granite has been subjected to very sev Government tests this season, and has proved super to others tested at the same time, and, as a result, granite for the monument to General Sherman is come from Woodbury.

At Ryegate the Blue Mountain Granite Company working a small quarry and are about to open a new in Tapham, just beyond the Groton line. Other quarr and works are reported as not running.

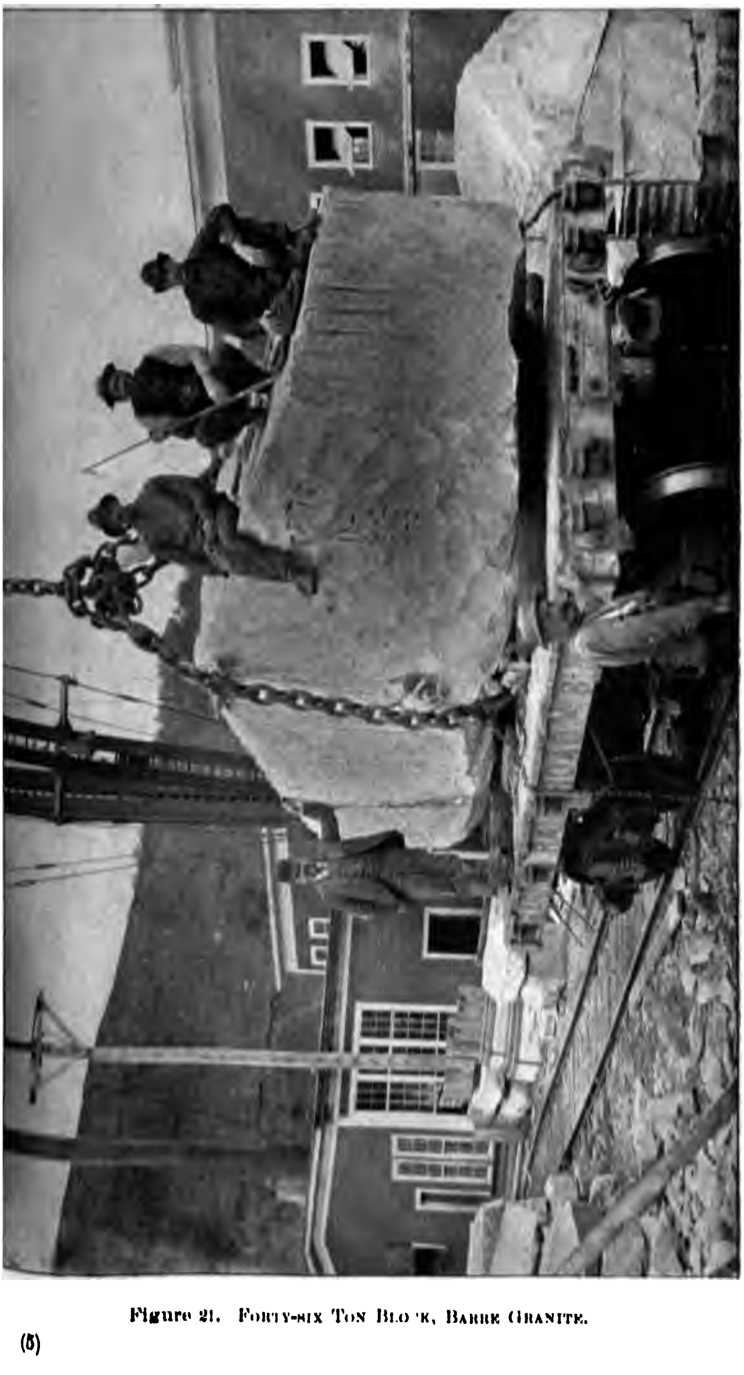


Figure 21. Forty-six Ton Block, Barre Granite.

hard, darker colored than any of our granites, and I doubt not durable.

I have already expressed my belief that Vermont has much prosperity before her if she will only make the most of her best resources, as seen in marble, slate and granite quarries. A correspondent who is in the best possible position to know, writes: "The granite industry in Vermont is only in its infancy, and the time is not far distant when Vermont will lead the world in the production of fine granite. The importance of the industry and the value of these deposits within the state have been ignored most by the people of Vermont. Foreigners and foreign capital have done the developing mostly." The sinews of quarrying are the same as the sinews of war. Money, capital, this is what the quarry interests of Vermont most need. After a quarry is well under way money begins to return, as the history of Barre well proves, but no successful quarry can be put in operation without large, and, at first, unremunerative outlay. The one most uniform expression of need that I heard at many quarries was that of more capital, and it was a call often well warranted by the condition of the quarries. There are quarries which would swallow up all capital invested as completely as if it were cast into the sea, but there are others which, if they could be further developed, would yield a much greater profit than at present.

Undoubtedly, here, as elsewhere, money will be lost and hopes disappointed because of the failure of what seemed promising quarries. Caution is well everywhere, but I think it is especially necessary, if one is to escape disaster, when investing in quarries or mines. Nevertheless, I believe that much wealth is to come to Vermont through the further development of her quarries, and that many profitable investments will be made. A well planned survey is only preliminary to investment, it is true, but it is a most important preliminary, and one that may prevent much financial loss, if it does not, as it may, secure financial gain.

UNIV. OF MICH.
[illegible]

Report of State Geologist

ON THE

MINERAL RESOURCES OF VERMONT

1899-1900

REPORT

OF THE

STATE GEOLOGIST

ON THE

Mineral Industries of Vermont.

1899-1900.

GEORGE H. PERKINS, Ph. D.,
State Geologist
Professor of Geology, University of Vermont.

BURLINGTON:
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1900.

STATE OF VERMONT.

OFFICE OF STATE GEOLOGIST.

BURLINGTON, VT., July 25th, 1900.

To His Excellency, Edward C. Smith, Governor of Vermont:

SIR :—In accordance with the provisions of Section 2, A No. 7, 1896, I have the honor to present herewith my report State Geologist for the years 1899 and 1900.

So far as was practicable with the very limited appropr tion at my disposal, I have sought to perform the duties whi the several Acts of the Legislature impose upon the Geologi

I am glad to acknowledge the hearty encouragement ai assistance which I have constantly received from you.

As Curator of the State Cabinet I have almost wholly r arranged the specimens and added many new species not pr viously represented. It is my hope that the changes made the cabinet will make it more attractive and instructive to tl many visitors who come to it. For a more detailed account the work accomplished, I would respectfully refer to the follo ing pages.

I may, however, add to what is given in the report that, accordance with your suggestion, I have in course of my inv tigations of the rock formations of the State, been on the loc out for deposits that could furnish suitable material for maca amizing, or otherwise improving, the roads. I am not present able to make a definite report upon this part of n work, but I hope to do so at a future time. In the meantime, shall be glad to be of such assistance as may be within n power to any who wish advice in this matter. I am, sir,

Very respectfully,

GEORGE H. PERKINS,
State Geologist.

REPORT.

INTRODUCTION.

Soon after his appointment as State Geologist in 1898, the writer published a Report on the Marble, Slate and Granite Industries of Vermont. This report was much less full and comprehensive than it would have been had there been more time for its preparation.

At that time it was hoped that in the report for the years 1899 and 1900, it might be possible to present a full and well illustrated account of the quarrying and mining interests of the State. The necessary funds, however, were not provided by the Legislature, and all that can be done in the present report will be to give such a statement as is possible under the circumstances, leaving the more satisfactory treatment of the topics considered until it may be practicable to present them without too narrow limitations. For the same reason much of the more strictly scientific material which is available is omitted as the publication of this would involve expense which can not now be incurred.

The present report is intended in some measure to supplement the previous one, since the same great industries, marble, slate and granite, are again considered and more recent facts given, but also the other mineral interests of the state are more or less fully discussed.

It has seemed necessary to devote this report to these subjects because during the past two years many letters have been received from almost every state in the union asking for information as to one or another of our mineral deposits, their extent, value,location, availability, etc. It is impossible to find answers to such questions in any published work and the demand has appeared to be so great that I have left aside other material to make room for such an enumeration of our mineral products as should serve in some measure to provide information for those interested in these subjects, though very imperfectly because of the extreme brevity with which each topic must be treated.

I have therefore mentioned in course of the following pages, all of the various useful minerals and rocks which are found in this state, giving such facts as have been obtainable as to localities, present condition of deposits and whatever other items appeared to be desirable. While it is hoped that in the main these statements are accurate, yet it is scarcely to be expected that no errors have crept in. It has not been possible to examine all of the localities named, personally, and, although several hundred letters of inquiry have been sent to owners or managers of mines and quarries, from many no reply has been received, and only very partial ones from others, so that much desirable information can not be given. It may be proper to remark at this point that if in the following pages certain firms are more fully mentioned and a better statement of their business given than others receive, this is in no wise because it is designed to give any one interest any advantage over others, but because it inevitably follows that if one firm furnish more complete statements than do others in response to inquiries, this firm will be more fully represented in any such report as this. It has been the intention to afford the same opportunities for furnishing information to all.

As has been noticed, there is a demand for information as to the natural resources of Vermont and a demand which is by no means local, but which comes from all parts of the country. This demand arises partly because some of the older mineral industries, such for instance as copper mining, have been greatly stirred to new and larger activity on account of new uses for their products and partly because wholly new industries have arisen and created new demands for material employed in their processes. Hence many old deposits, formerly worked at a loss, are now reopened and found profitable under the new conditions while heretofore useless materials are now become of value.

In what was said above I do not at all intend to intimate that consumers of mineral products are looking to Vermont alone for a possible supply, but only that they are looking this way as they are looking in every direction, and that state which can most promptly and satisfactorily answer their inquiries will secure the business which may arise. For this reason, the Geologist has considered it not the least important part of the work of his office to correspond with those who might be purchasers of our products. This correspondence has grown to large proportions.

For the same reason, there is great need of a thorough and systematic exploration of the state in order that its mineral resources may be better known than they are at present. It will take both time and money to accomplish this, but both would be well spent and would unquestionably bring very material returns in increase of business, not to mention the scientific value of the facts which would be thus gained.

In proportion to her population Vermont has greater wealth in quarries than any other state and it is only common business wisdom to ascertain all that can be known of these quarries and the deposits in which they are located and, having gathered the facts, to publish them so that anyone interested may have access to them.

Vermonters may reasonably be proud of the marble, granite and slate beds which are their possession, but something more practical than pride is necessary in order that these already great interests may be developed as fully as possible, for the increased prosperity of these means the increased prosperity of the state.

While here and there quarries have been given up temporarily or permanently, I believe it to be true that on the whole, there is greater activity in these industries than ever before. That is, there is at present a larger amount of capital invested, a larger number of workmen employed and a larger and more valuable output than at any time heretofore. Of course this is not true in all cases, but as a general statement I think that it is.

During the past year there have been at least two hundre quarries of various sorts operated in the State. In these an in the mills connected with them there are employed eigh thousand men. The capital invested amounts to over $6,000 000. The stone quarried is valued at $6,500,000. The annu cost of working these quarries and mills is $4,000,000. Whil some firms report a decrease in business, most report an increase, some a very considerable increase.

I have spoken only of quarries for two reasons. First Vermont never has been and never can be a very important mining state. I do not mean by this that there are no good mines. I think that in a few localities copper mining may be profitably carried on as will appear later, but these localities are limited and the work carried on in them can never approach that which is going forward in the great quarry regions.

METALLIC PRODUCTS.

COPPER.

The only mining in this state which has ever been carried on to any large extent is that of copper. As will be noticed later, other metals have been found in the rocks of Vermont and at times iron has been obtained in considerable quantity, but far more extensive than other mining operations have been those for copper. The unusual demand for copper which during the last few years has been produced by its use in electrical equipments and the consequently increased price of the metal has aroused new interest in all deposits from which it could be obtained.

There is no native copper, like that found in the Lake Superior region, in Vermont. Our copper ore is nearly all of it chalcopyrite, or copper pyrites, a sulphide of copper, which may be and usually is, largely mixed with pyrrhotite, or iron sulphide There is in one locality another ore, bornite, or copper and iro sulphide. In the Report on the Geology of Vermont 1861, p 850 there is a very good account of the earlier efforts at coppe mining in this state It appears from this account that coppe has been to some extent mined in Vermont for at least eighty years, though at times there have been intervals of entire inactivity.

At present copper is being mined at the old Ely mine in Vershire, at the Elizabeth mine in South Strafford, at the Reynolds mine in Strafford, and at the mine of the Vermont and Boston Mining Company in Berkshire. There are other localities in which some little prospecting has recently been done, but I know of no real attempt at mining at other places than those named. Formerly there were two mines in Corinth which were quite extensively worked, but without very much profit, so far as I can ascertain. The statistics of copper production in this state for the past fifty years show very great and often sudden fluctuations in the amount of ore raised and of metal extracted. In 1860 about 1500 tons of ore were mined, in 1870 1000 tons, in 1880, 28,000 tons from which 2,647,900 lbs. of metallic copper were smelted. In 1883 this large quantity had shrunk to 400,000 lbs. of copper and then during the next ten years the amount was very small or nothing, in 1890 the amount was only 72,000 lbs. During the past year, 1899-1900, the Elizabeth mine has produced not far from 2,000 tons of ore and during the past ten years this mine has produced 50,000 tons most of which has been shipped to other states for smelting.

As has been stated, two mines were formerly worked with some energy in Corinth. A few words as to these may not be without interest as history. For many of the facts given I am indebted to a paper by Gov. Farnham in the Report of the Board of Agriculture, 1872.

At one time these two mines, the "Corinth" and the "Union" employed two hundred men. The "Corinth" produced about 150 tons of ore monthly, all of which was shipped elsewhere for smelting. But these times of activity seem to have been of no long duration. The closing of these mines does not appear to have been caused by diminished quantity of ore, but rather because the methods employed in getting out the ore and reducing it to copper was such as to cost more than the copper obtained was worth.

The most famous mine in Vermont has been the Ely a Copperfield, Vershire. This mine has been more extensivel worked than any other in the state and for several years pa dividends and in 1872 it was producing metal at the rate $300,000 worth a year and employing three hundred men a boys. "The dip of the vein is towards the east and for t first three or four hundred feet from the surface is about 30 but for the last few hundred feet that have been worked it i only 23°. Since 1854, the main shaft has been pushed down o the vein until now it has reached the depth of nearly nine hundred feet from the surface and a new adit has been driven in until it reaches the main shaft, a horizontal distance of nearly eight hundred feet." This was in 1872. The draining of this mine was unique. So little water entered through the compac rock and the ore body itself was so far above the valley tha drainage, which is often the most costly and difficult part o mining, is here very easily accomplished. All the machiner needed was a tank which was drawn into the mine and the wat which had accumulated in a reservoir blasted out for that pu pose was dipped into it and drawn out. It is said that only few daily trips were needed to drain the whole mine. The bes ore, the pure chalcopyrite, affords on the average some twenty five to thirty per cent of copper, but most of the ore is largely mixed with iron sulphide so that the average of the ore as mined is very much less, not more than three per cent. or in better portions, four per cent.

After years of mingled prosperity and adversity, this mine was closed and for some years nothing was done there. The mine filled with water, the machinery rusted, the imposing row of smelting furnaces stood dismally silent and empty and everything about the place wore an air of desolation and ruin Within a few months, however, the property has been bonde to Mr. George Westinghouse, of the Westinghouse Air Brak Company, and about $60,000 I am told has already been expended in repairing the dilapidated buildings and machiner and putting in new. The mine is being pumped out and the old ore dumps are being worked over, ore is mined from the upper part of the deposit, exploration is going forward, a hundred and fifty men are at work, ore is crushed and reduced to matte in a reverberatory stack roaster. The Superintendent writes that the mine following the vein, which, as noticed above, dips 23°, is 3,300 feet in from the surface and the vertical depth is 1,500 feet.

The oldest mining locality in the State is that at South Strafford, the property of The Elizabeth Mining Company. Only a few rods from the present mine there is an enormous trench from which as long ago as 1793 pyrite, iron sulphide, was mined for the manufacture of copperas. For many years this was carried on, indeed, mining of some sort appears to have been going on at this place with little, if any, interruption ever since the above date. For a long time, however, copperas, not copper, was the object of the miners. After a time the copperas mine was abandoned and shafts were sunk north of the old trench and now the ore sought was that which would produce metallic copper. For a considerable number of years the Messrs. Tyson have carried on the mine and have expended much money and labor in developing the ore body.

The Elizabeth Mine is in many respects very favorably located. Although the nearest railroad station is at a distance of over eight miles, that at Sharon on the Central Vermont, and the station of the Passumpsic at Pompanoosuc is ten miles, yet the roads to these stations are well kept and the grade from the mine is mostly descending.

What is of more importance, the mine being situated in a side hill at a considerable height above the valley lying to the east, drainage is readily secured.

The rock in which the ore is found is mainly mica schist and the ore is substantially the same as at Copperfield, chalcopyrite, associated with a large proportion of pyrrhotite. It is probable that the mass of ore here is larger than anywhere else in the state. At any rate it is enormous. As at present, 1900, developed, the ore body is a mass 1,000 feet long, 240 feet high and 35 feet wide, but it is evident to anyone wh examines the mine that the full dimensions of the whole bod have never been disclosed.

The ore is most of it low grade, from two per cent to si per cent only being copper, but some of it contains much more ten to fifteen per cent, and at times ore is found which afford from twenty five to thirty per cent. The ore body is in th form of a "chimney" or "lens" which pitches towards th north. It is reached chiefly by an adit 1,400 feet long whic has been worked in through the hillside. This adit, or tunnel inclines 20° as it goes in. Higher up on the hillside ar three shafts, the deepest of which reaches down 150 feet There are three levels on which the ore has been worked o "stoped." The deepest of these is 300 feet below the surface Everywhere the excavation shows the presence of ore and th deeper stopes give the best. In September, 1899, about 50,0 tons in all had been taken out. The crushers, furnace, etc are all below the entrance to the adit so that loaded cars car the ore from the mine by gravity. Until within a few month the best ore has been shipped to New Jersey where it w smelted, while the rest was piled in quadrangular heaps, eac being about 40x23x8 feet and containing some three hundre tons of ore. Each pile is built on a layer of dry wood which is set on fire and the heat soon frees sulphur enough to supply fuel for the remainder of the process which lasts about two months. The residue is a black mass of iron and copper from which the copper must be separated. Mr. Tyson writes that there are now, September, 1900, twelve thousand tons on the roasting beds. Last November a reducing furnace was completed and since then ten thousand tons of ore have been reduced to "matte" which contains some thirty to forty pe cent of copper. "During the past year we have been sinking below the adit level and find a superior quality of ore and the whole north end shows a 4.6 per cent ore."

The furnace mentioned above is now smelting about 12 tons of ore daily and in and about the mine 140 men are employed.

As has been stated, the ore at the Elizabeth mine is chalcopyrite, copper sulphide, mixed with a greater or less amount of pyrrhotite or iron sulphide. The relative proportions of these minerals vary very greatly. Usually the copper sulphide forms only a very small part of the ore brought out, but in some parts of the ore mass the copper sulphide exists as a much larger part of the whole. The average of the ore used is stated as being five to six per cent. A complete analysis of average ore furnished by the company, is as follows:

Copper	5.01	per cent.
Alumina	8.97	"
Iron	30.99	"
Silica	27.95	"
Sulphur	21.77	"
Lime	1.68	"
Magnesia	2.36	"
	98.73	per cent.

The metallic copper from this mine is said to be of very excellent quality, much above the average.

Besides copper, the ore sometimes contains in small quantity both gold and silver. "About 2 ounces of silver and 0.8 pennyweight of gold per ton." Hitherto these metals have not been taken into account as the methods used for the extraction of copper were not such as favored getting the other metals and it would cost more to get them than they would be worth. Different processes, however, might make it possible to save even so small an amount of the precious metals. And, though the value in each ton is so small, yet when it is multiplied by the total number of tons annually produced the sum becomes eminently respectable, perhaps not less than $40,000 for a year.

From South Strafford on north through Strafford to Vershire, there are outcrops of copper bearing ore, but none of these are worked except at what is known as the Reynolds mine in Strafford. This is at present in the "prospect" stage, but the indications are promising. It is located about a mile north of the village and was worked somewhat about thirty years ago and some very good looking ore taken out, but the work was for some reason soon given up. By the present working, the shaft has been carried down about a hundred feet where a cross cut is being made. A vein of good ore ten feet wide has been found.

The only other mine now working in the state, is that of the Vermont and Boston Copper Mining Company at Berkshire. About a year and a half ago, this mine was opened and now the shaft is a hundred feet down and from it there is a drift eighty-five feet long. The superintendent reports that "Large bodies of chalcopyrite and bornite have been opened up. Assays from 5 per cent. to 60 per cent."

GOLD.

In many places in the state gold has been found, but no where in paying quantities. Most commonly it occurs in th sand of streams, but in some places, as at Plymouth and Bridge water, gold bearing rock has been found and mined. So far a I can ascertain, in all of the localities the cost of getting the metal has been more than it was worth. There is no probability that it will ever be otherwise in this state. It is therefore useless to spend time and money in trying to find a fortune in gold mining in Vermont. Considerable money has been lost because it was invested in such mining, but I have yet to hear of much that was made in this way in this state. Occasionally a little "pay dirt" has been found, but in a short time the promising mine has been left unworked.

In 1865 there was, if we may judge by reports, a stir of excitement over the golden sands of White River near Gaysville and Bethel, and for a time it really seemed as if something might come of it all. So much interest was excited that, first and last, a considerable sum of money was invested in labor and machinery. After a short season of apparent prosperity, however, the enterprise was abandoned. Several hundred dollars worth of gold was obtained from this locality, if reports are true, and in all quite a little amount must have been taken out in Plymouth, but it is not possible to get any very definite statements as to the amount.

What is true of all mining is especially true of gold mining. It is exceedingly uncertain business. If anywhere in nature lawlessness rules, it is in the arrangement of mineral veins. They may pass from rich to poor, or wide to narrow, very suddenly and apparently without any reason whatever. About all that is sure in a vein of ore is that part which is actually in sight. Hence whoever goes into mining should distinctly understand that he is engaging in a very risky business, though a perfectly legitimate business. Much money has been made in mining, but much has also been lost.

It is well for those who think that they have found gold bearing rock to know that locating such ore does not by any means insure a fortune or any part of it. It is always necessary to take account of the cost of getting the metal out of the rock or ore. It is quite possible to find a vein of gold bearing quartz, for instance, which is of little or no value to its owner because the expense of getting the stone out of the ground and then getting the gold out of the stone would be more than the gold would be worth. The process of separating gold from quartz is complex and involves the use of expensive machinery and nothing of importance can be done with even a rich vein until such machinery is provided.

Another important fact is that a quartz vein is not always, nor usually, gold bearing. The world is full of quartz veins and masses which are quartz and only quartz. These remarks will undoubtedly seem quite unnecessary to many who may read these pages, but more than once, indeed not seldom have I found persons in this state trying to start a gold mine with evidently no conception of what was before them if they carried out their plans to any completion, the sole foundation for their hopes being that they had found a mass of quartz that had a little gold in it, or, even less promising, quartz that looked like that from some western locality in which gold had been found.

Much time, labor and money have been wasted from failure to attend to facts like those noticed above.

In this connection I wish to correct an error which has stood uncorrected for a long time. In the Vermont Agricultural Report for 1874, there is an article on Gold Mining in Vermont, in which it is stated that with the gold taken from an island in White River there had been found the rare metal iridium. The statement was undoubtedly made in good faith and what were supposed to be specimens of iridium were exhibited.

It seemed, however, so extremely improbable that iridium has ever been found in Vermont that I have been at some pains to investigate the above statements and it appears to be certain that no such metal was ever found in the locality named, or anywhere else in the state, but that those who supposed that they had found it mistook grains of specular iron or some similar metal common in the White River sand, for the rare iridium.

LEAD.

Galenite, the common ore of lead, is found in small masses in many parts of the state, but nowhere has it ever been successfully mined. Some of the veins which I have examined are of excellent quality, but do not afford a sufficient quantity of ore to make development worth while. I do not find that there has ever been any very serious attempt to mine lead anywhere in the state. Some attempt, however, has at different times been made to work lead mines in Thetford, Norwich, Morristown, Bridgewater, Brandon, Chittenden and perhaps at a few other localities, but without important results.

IRON.

Many towns in the state possess some sort of a deposit of iron, but for many years no iron of any value has been produced in Vermont. So far as I can ascertain, no ore beds are now worked in the state.

Iron occurs in the state in a variety of ores. The bog ore, limonite, is most commonly found. Beds of this have been worked near Brandon, Monkton, Bennington and other localities, nostly in the southern part of the state. The Brandon beds were it one time of considerable importance to the state. "Iron ore was first discovered in Brandon in 1810, and soon after a forge was built and bar iron of superior quality was manufactured for everal years. In 1820 a furnace was built by John Conant." In 1850 this furnace was bought by the Brandon Iron and Car Wheel Company and in course of a few years a capital of $175,000 was paid in. But ill fortune came upon this promising enterprise and t was finally given up. Associated with the iron were ochre, clays, kaolin, etc.

Magnetite in small amount occurs at Bethel, Rochester, Bridgewater and is the most common ore found in the black sand of many streams.

Specular and titaniferous iron are found in a few localities. A bed of carbonate of iron, siderite, was worked for some time at Tyson furnace. Chromite, or chromic iron has been found in the northern part of the state, at Jay, Westfield, and Troy and to a mall extent in the southern part, as at Newfane. At the Jay ocality several tons of this ore were taken out in 1871. About he same time over 100 tons were mined and shipped in Westield, but the work ceased in a year or two.

According to the U. S. Census Report for 1880, Vermont produced in that year 250 tons of metallic iron, but after that date little, if any, was produced.

MANGANESE.

Bog manganese is found here and there all over the state, but s of no great value. The manganese ore found at Brandon is psilomelane and is of much more value. Another ore of manganese is braunite, which is found in Brandon, Plymouth, Bennington and a few other places. Pyrolusite is also found in the same ocalities. I can not ascertain that manganese at present is mined anywhere in the state, but until recently more or less was obtained and sold. In 1888 not less than 1,000 tons were sold, but in 1891 only 49 tons were mined and since then none of any onsequence.

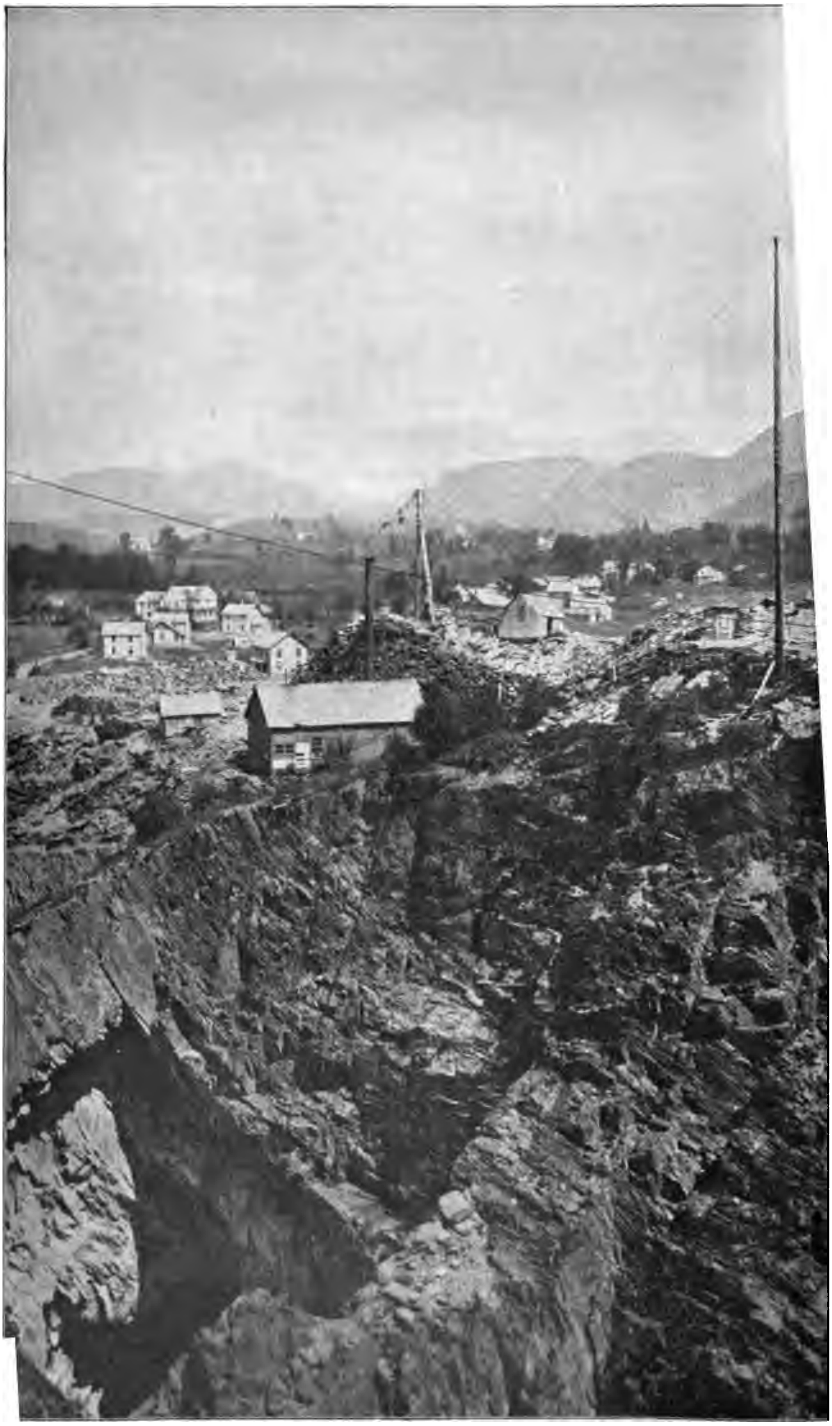

FIGURE 1. SLATE QUARRIES AT WEST PAWLET, LOOKING NORTHEAST. The hills in the background are a portion of the Taconic Range and are chiefly composed of schist. From the V. S. G. S.

SLATE.

The slate business in Vermont has on the whole changed but little during the last two years. A number of new quarries have been opened, some old ones abandoned. I think that a larger number of quarries are now in operation than two years ago. Most of the firms engaged in this business report increased sales during the past year. This is especially true of those quarries that produce the variety of slate called unfading green, for which the foreign demand continues brisk. Other varieties of slate are exported, but none is in great demand abroad except the unfading green. The foreign trade has saved more than one company from serious trouble. The extent of this export trade may be seen from the following extract from a recent letter which I have received from one of the large quarries. "We are loading to-day, two cars for Durban, S. Africa, twelve for London, six for Bristol and Newcastle." Most of the quarries which are not so fortunate as to possess the unfading green, report little or no increase, and some a decrease, in their business.

While nearly all the productive quarries are in western Vermont, slate has been quarried in past years in many parts of the state, to a greater or less extent. Most of these quarries have been abandoned for many years, though some were worked considerably for a time. At present no quarries are worked outside of Rutland county, except one or two at Northfield.

The great slate belt of Western Vermont begins on the north near Glen Lake at West Castleton, though the first bed which is worked is that at Cedar Point on Lake Bomoseen, six miles north of Fair Haven. It extends southwards on each side of Lake Bomoseen, especially on the west side, through Scotch Hill, where some of the first quarries in this region were opened in 1839, and something has been done at this place ever since that time. From Scotch Hill the belt may be followed through New Haven on to Blissville, Poultney, South Poultney, Wells, Pawlet, to West Pawlet, south of which place there are no Vermont quarries now worked, though formerly there were quarries as far south as West Rupert. The adjacent New York quarries in

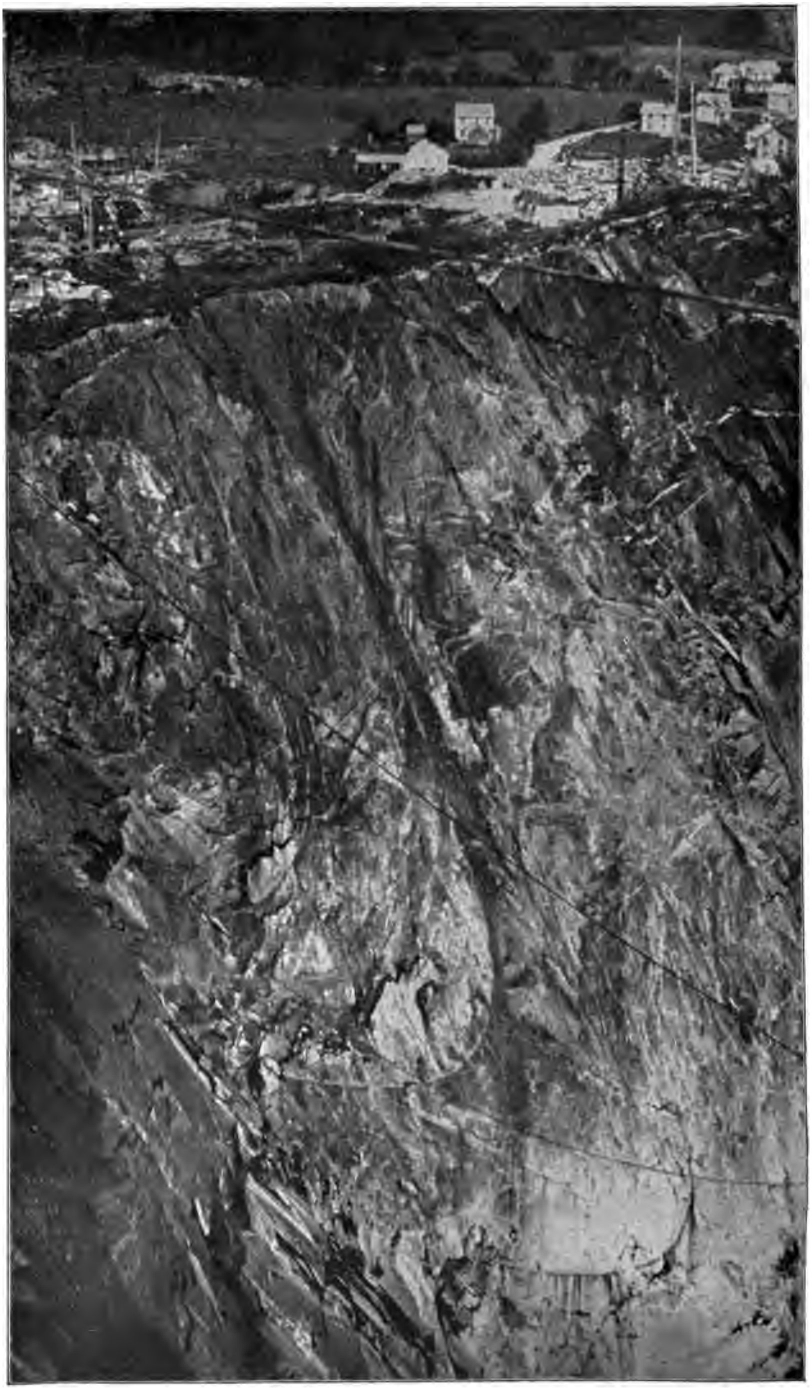

FIGURE 2. INTERIOR OF ONE OF THE DEEP SLATE QUARRIES AT WEST PAWLET. In the lower left-hand side of the figure, between the cables, is seen a *synclinal fold* in the slate. From the U. S. G. S.

Washington county reach considerably farther south than those in Vermont. The Vermont slate region is, as indicated, about thirty miles in length from north to south. In width the area is nowhere over eight or ten miles, and for the most part not more than five or six miles. From a little south of New Haven the quarries, with some rather long interruptions, are very closely located, being at some points contiguous, and the forest of derricks forms a conspicuous feature in the landscape as one approaches the place. The dump heaps, which are sometimes enormous, are also very conspicuous. Most of the quarries are deep pits which begin on the top of a high ridge as rectangular openings of greater or less dimensions from which the stone is removed downwards. It is not easy to get a good view of any of them. Figures 1, 2 and 3 show the interior of the West Pawlet

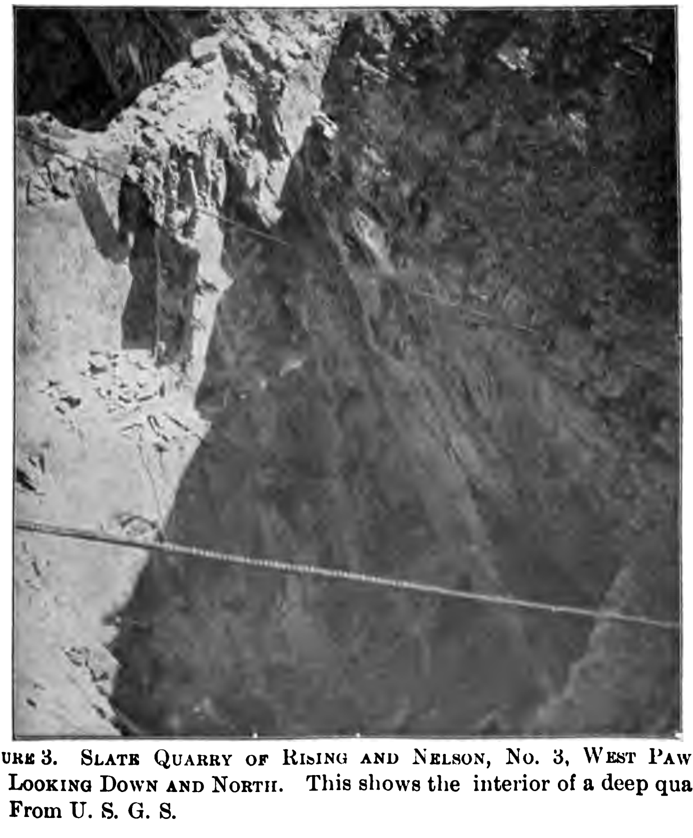

FIGURE 3. SLATE QUARRY OF RISING AND NELSON, NO. 3, WEST PAWLET, LOOKING DOWN AND NORTH. This shows the interior of a deep quarry. From U. S. G. S.

quarries. These may be two hundred feet or more in depth. Figures 4 and 5 show the quarry at Cedar Point which, unlike most, is a side-hill quarry.

Within the Vermont slate area there are worked and abandoned, permanently or temporarily, about a hundred and fifty quarries. These quarries produce a number of varieties of slate which have quite different market value. No black slate is found in this belt. The varieties are, unfading green, sea green, purple, variegated and in one quarry, Griffiths and Nathaniels at Poultney, there is a vein of a dark gray called Poultney Gray. In many of the beds the color of the slate is very uniform and free from spots, but that from other beds is often spotted and this of course greatly damages the stone as it makes it unfit for market. In purple or red slate, the spots are green, or at least of a greenish hue. The spots may occur throughout a bed, or only in a part of it. The spots appear to contain less iron oxide and more lime carbonate and also more of the carbonates of iron and manganese than the rest of the rock. There is also more silica, for which reason the spots are harder than the rest. The less quantity of iron oxide $Fe_2 O_3$ is supposed to be due to the decomposition of organic matter, fossils, and the increase in carbonates is caused in the same way. "In view of all these facts and indications, the spots may safely be regarded as probably produced by chemical changes in the sediments consequent upon the decay of organisms."*

The increase of quartz is supposed to be due to infiltration from the surrounding rock.

Anyone visiting the slate quarries of Rutland county, Vt., and Washington county, N. Y., would naturally regard them as parts of the same formation, but as will be seen later, they do not belong to the same age. Most of the New York quarries are later in age than those in Vermont, though some of them are within a stone's throw of each other. Both areas together extend about fifty miles from north to south and are, as estimated by Mr. Dale, seven miles in average width, and nowhere is the combined area over ten miles in width. In this area there are in all some two hundred and fifty quarries of which, as has been stated, a hundred and fifty are in Vermont.

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* Slate Belt of Eastern New York and Western Vermont, page 258. T. N. Dale.

In my report of last year the erroneous statement occurs that both areas are geologically the same. I regret that this mistake should have been made, for it is some time since Mr. Walcott, by a careful examination of fossils, showed that the Vermont slate was of a different age from that of New York. By most diligent exploration he found fossils in one hundred and fifty-four localities and later came the extremely thorough and important survey of the region by Mr. Dale, who has added to Mr. Walcott's fossil localities no less than one hundred and eighty nine. As a result of the above investigations, it is settled beyond doubt that the slate of Rutland county is Cambrian, while that of Washington county is Ordovician (Lower Silurian.) As to this Mr. Dale remarks, "The Cambrian roofing slates are, therefore, regarded as occurring not far from the top of the Lower Cambrian series as exposed in this region and very near the overlying Ordovician. As the Cambrian beds are made up of numerous folds, generally close and overturned, the slates also occur toward the center of the belts, but their stratigraphical position is the same. The first place to look for the Cambrian roofing slates is near the Cambro-Ordovician boundary. Where the red slate occurs in close proximity to, and on the west side of, the Cambrian roofing green and purple slates, and the dip is easterly, as it usually is, the red slate may be found underlying the sea green, unfading green, or purple slates and vice versa; on the eastern side of the Cambrian areas, the green and purple slates of the Cambrian may be found underlying the red of the Ordovician when both dip easterly. At several points (Blissville, Eureka, etc.) away from the Ordovician boundary, the rock which appears to immediately underlie the Cambrian slates is the olive grit, one of the so called "wild rocks" of the quarrymen. The rock which overlies the Cambrian slate is either the "Black Patch grit," or the Cambrian black shale, or the Ferruginous quartzite and sandstone. Most generally, there is a bed of limestone conglomerate or breccia, followed by black shales or slates. These vertical relations are pretty well established.''*

It is a very interesting fact that all the red slate is Ordovician while all the purple and green is Cambrian and it is mos probable that the black slate of Benson is Ordovician, as i pretty well established in case of the black slate of Northfield

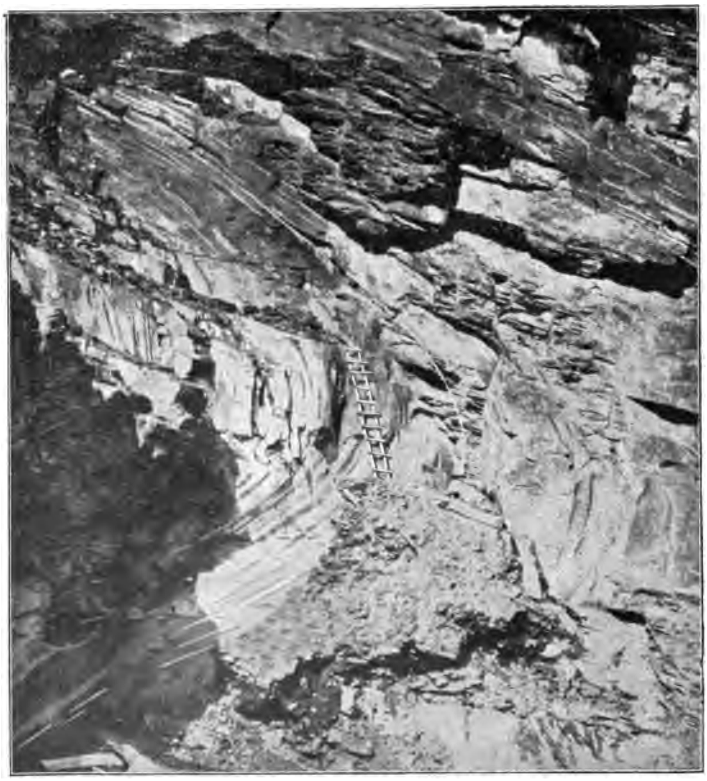

FIGURE 4. VIEW IN THE SLATE QUARRY AT CEDAR POINT ON LAKE BOMOSEE
The ladder, about 13 feet long, is placed against the synclinal fold the slate. The fold has been overturned and lies on one side. Th syncline strikes N. 10° W. From U. S. G. S.

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* Dale l. c. p. 265.

as was shown in the last report. In the slate belt, these two areas, the Cambrian and the Ordovician, are curiously intermingled. The Cambrian occupies a greater area, but its territory is invaded in a very complicated manner by tongues, promontories and islands of Ordovician. To the eastward of the slate belt in Vermont the rocks are Ordovician. In the slate region, the rocks are quartzite, which is perhaps most abundant of all, limestone, schist and shale. The whole is covered to a considerable depth by glacial drift. The higher portions of the Taconic range, which runs north and south, east of the slate, are mainly schist. Some of these are seen in the background in Figure 1. According to Mr. Dale, the lower hills are mainly quartzite. The slate does not always form a mass by itself, but not infrequently it is intermixed with quartzite, which may be calcareous. These quartzite beds may be only a few inches thick, or they may be several feet and, as would be supposed, they may greatly interfere with the value of a slate deposit. Above the slate, beds of calcareous conglomerate often occur, and in these fossils, Olenellus, and other Cambrian species are found.

The slate beds are quite differently situated in different quarries. In some the slate beds are nearly horizontal while in others and most, the beds are inclined or folded. In the quarry at Cedar Point, on Lake Bomoseen, the purple slate is folded and the folded mass turned over so that it is like a letter v, laid on the side, that is, it is what is called an overturned syncline. Figures 4 and 5 show this structure as does Figure 2 which shows the same synclinal arrangement in one of the quarries at Pawlet. In the Eureka quarry at Poultney, Mr. Dale reports the following layers. Beginning at the top, there are : Purple slate, 20 feet ; not named, about 30 feet ; variegated slate, 20 feet, followed by a second bed of the same about 2 feet ; green slate, 30 feet ; light green slate, 20 feet ; gray green slate, 11 feet ; gray green, 18 feet; quartzite, 4 feet; gray slate with black patches, 20 feet. This is more complex than is usual in the quarries. At the Lake Bomoseen quarry, shown in Figure 4 there are 127 feet of purple slate above which are 50 feet of green. At one of the Fair Haven quarries the order of beds is, below the surface rock, 18 feet of variegated slate, then a thin layer of quartzite, then 13 feet of green slate, followed by a thin bed of quartzite, below which are 20 feet of green slate.

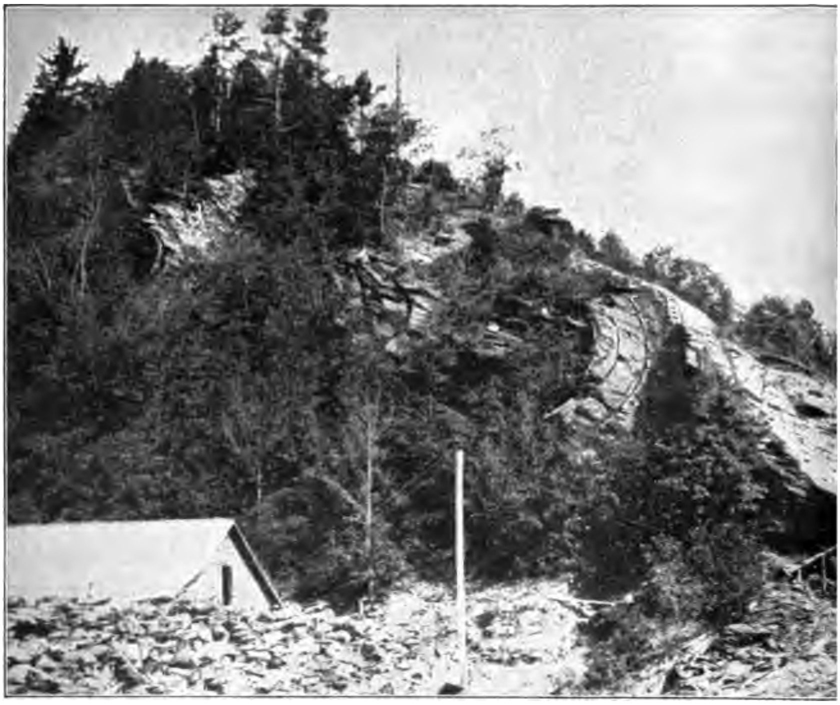

FIGURE 5. VIEW AT THE SLATE QUARRY AT CEDAR POINT. The same syncline seen in figure 5 is shown at the right. From the U. S. G. S.

The total area as previonsly outlined, is about two hundred and fifty square miles. To this should be added, for the entire slate area of the state, about eight square miles of black slate in Benson and a small area in Northfield. The larger part of the quarries produce only roofing slate, but a few, as that at Cedar Point, and one or two at Scotch Hill, produce what is known as mill stock which is a somewhat more compact stone having a less perfect cleavage. This is sawed into slabs for billiard table tops, tiles, blackboards, etc.

The color of the slate varies in different localities. In some quarries all the slate is purple, in others both purple and green, in others it is all green. And, as the section given above shows, there may be several layers of each color in a single quarry.

The difference in color is due to difference in composition.

In Mr. Dale's Report, analyses by Dr. W. F. Hillebrand are given and from these I quote the following :

NALYSES OF ROOFING SLATE, MADE BY DR. W. F. HILLEBRAND, U. S. G. S.

Constituents.	Sea Green.	Unfading Green.	Variegated.	Purple.	Benson Black.	Red. New York.
$_2$ Silica	63.33	59.37	60.24	61.29	59.70	63.89
$_2$, Titanium oxide	.73	1.00	.92	.77	.79	.52
$_2$ O$_3$, Alumina	14.86	11.93	18.46	16.24	16 98	11.80
$_2$ O$_3$ Ferric oxide	1.12	1.18	2.56	4.53	.52	4.56
O Ferrous oxide	4.93	6.69	5.18	2.62	4.88	1.33
O Lime	1.20	.49	.33	.60	1.27	2.25
O Magnesia	2.98	2.36	2.33	2.99	3.23	4.57
O Potash	4.06	3.78	4.09	5.27	3.77	3.95
$_2$ O Soda	1.22	1.71	1.57	1.38	1.35	.50
$_2$ Carbon dioxide	1.41	.30	.08	.54	1.40	3.15
S$_2$ Pyrite	.11	.14	.16	.04	1.18	.92
$_2$O Water above 110C	3.37	4.91	3.81	3.16	3.82	2.82
Carbon	Trace				.46	
ndry and Water below 110,c	.69	.51	.39	.56	.70	.77
tals	100.01	100.05	100.12	100.09	100.05	100.13
ecific gravity	2.776	2.795	2.805	2 806	2.774	2.796

A careful study of the above table gives us a clue to the use of the different colors seen in the slate of different beds. also shows that slate is quite complex in its constitution. We that the green slates contain less iron oxide, ferric oxide, n the purple or red. Thus we find that the purple and red tes contain four times as much ferric oxide as the green. Mr.

Dale gives the following summary of the mineral composition of the different varieties:

"*Sea green.* Largely muscovite (potash mica), quartz, chlorite, carbonate (dolomite with siderite), pyrite, with very little lime-soda feldspar, still less zircon, rutile, cryptocrystalline quartz lenses.

Unfading green.—The same as above, but with much less carbonate; more pyrite and chlorite.

Variegated.—(Eureka).—Like the unfading green, but with irregular areas over which hematite is thickly disseminated.

Purple.—Like the sea green, but with less carbonate, less FeS_2, and more thickly and evenly disseminated hematite, Fe_2O_3 than in the variegated.

Red.—Not so largely muscovite, very thickly disseminated Fe_2O_3. More carbonate, but less iron carbonate and less pyrite than in any of the preceding. Quartz, carbonate of manganese, chlorite, very little plagioclase, feldspar, zircon, little rutile, tourmaline.

Black.—Matrix like the other slates, of potash mica. Carbonates about as abundant as in sea green, quartz, less Fe_2O_3 and more FeS_2 than in any of the others Rutile, coal, or Graphite."*

As is well known, the sea green and purple slates do not retain the color seen when they are first quarried, but after exposure in the open air they turn a yellowish brown.

This change is due to the presence of numerous little masses of iron and lime carbonates. The iron, which is at first almost without color, and therefore, does not affect the general shade of the whole, is oxidized on exposure to dark brown limonite and this gives tone to the whole. There are few of these oxidizeable masses in the unfading green which on this account does not change color. While I have visited most of the worked quarries in Rutland county and to some extent explored the whole slate area, I wish to express my very great obligation to the report by Mr. Dale, to which I have frequently referred in the preceding pages. It is by the courtesy of Hon. C. D. Walcott, Director of the U. S. geological survey, that I am able to use figures 1, 2, 3, 4, 5, which are taken from Mr. Dale's report. I would most earnestly commend this report to anyone who wishes information concerning the slate of Vermont and New York. Nothing upon this subject at all comparable with it has ever been published. It is published as one of the monographs in the Nineteenth Annual Report of the United States Geological Survey, Part III, Economic Geology, pages 153–307. *The Slate Belt of Eastern New York and Western Vermont.* Maps and Plates, 1897-98.

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*Dale l. c. p. 264.

As this report is intended less for scientists than for the general public, it may be well to notice that slate is not formed, as is shale, by thin bedding when deposited. Many confuse slate and shale and I have, in this state, more than once been invited to examine a "slate" quarry which was merely a bed of shale. Slate is always a rock that has to some extent been modified from its original condition and the cleavage of the slate is never in the plane of bedding and usually the slate splits at a very large angle with the plane of bedding or stratification. Shale on the other hand splits in planes wholly parallel with the stratification of the rock mass, indeed it has no cleavage like slate, but is simply a thinly stratified rock. As to the cause of slaty cleavage, much has been written and this is not the place for a discussion of the question. It is enough to say that it seems to be produced by strong lateral pressure against a plastic, but firm bed of compact material which is held firmly on the side opposite the pressure. In this way a cleavage more or less vertical to the plane of stratification is produced.

It has long been known that slate that had been exposed to frost was much injured and would not split as freshly quarried blocks may. Experiments made in the laboratory of the U. S. G. S. have shown that freezing and thawing change the texture of the stone and partially or wholly destroys its cleavage.

As has already been noticed, there is an area about eight square miles in extent at Benson, a few miles north of the great belt we have been studying. All the slate here is black and some of it appears to be of very good quality but none of the deposits are now worked.

East of the Green Mountains at Northfield there are a number of quarries of black slate, only one or two of them now worked. The reason usually given by those who may be supposed to know, for the closing of these quarries, is that they are owned by people living outside the state who do not care to put their money into their development.

It is said that slate was formerly quarried at Thetford and that at one time quite a large amount was obtained. In Guilford two beds of slate were worked for a time. One of these was worked by the New England Slate Co. as early as 1812, and is, therefore, one of the first slate quarries opened in the state. There were also quarries at Fairlee, Waterford and elsewhere.

Pennsylvania leads the country by a long way in the production of slate, but Vermont comes next, though not producing nearly so much, the total amount being only about a third of that furnished by the larger state. In 1898 Vermont produced slate to the value of $732,684, which was a considerable increase over 1897, and there is every reason to believe that a still larger quantity was sold in 1899, and that yet further increase will be noted in 1900. The largest sales of slate made in this state were in 1892, when they amounted to $1,014,000. In 1893 the sales declined to little more than one-half those of the previous year, and then a slow increase followed and this has continued until the present, when the sales are larger than in any previous year since 1892. It has not been possible to collect full and accurate statistics of the slate industry in Vermont for the past two years, but from the reports which have been sent in, and from such inquiries as I have been able to make, I think that it is quite within the limits of truth to say that there are at present twelve to fifteen hundred men employed in the mills and quarries, over half a million dollars invested in the business, over $700,000 paid in wages, and an output valued at nearly a million dollars, and this is increasing.

In concluding what I wish to say of the slate of Vermont, am sure that I can do no better than quote once more from Ir. Dale's report, condensing his statements.

After noticing that the geological history of the slate belt annot be wholly made out as yet, he says: "Some of the main utlines, however, as generally received, are as follows :

First. A land surface chiefly of granites and gneisses.

Second. The advance of the sea in the earliest Cambrian. he nearest land masses then were the Adirondacks and adjacent re-Cambrian masses on the northwest and portions of the Green Iountain range on the east.

Third. The deposition of the lower Cambrian sediments om the products of erosion of these land masses. These sedi-ents were mainly sandy and clayey, but sometime calcareous nd then largely of organic origin. The frequent alternation of ne and coarse sediments and of these with calcareous ones, and e recurrence of conglomerates, indicate changing conditions. here was deep and shallow water, quiet water and rapid cur-ents, occasional exposure of the sea bottom to wave action and en its submergence, owing to minor oscillations of the earth's rust. Slates and their interbedded quartzites correspond to ex-emely fine argtillaceous sediments from the waste of granites d gneisses, and to coarse sandy ones representing coarser aterial.

Fifth. The lower Cambrian sediments are followed by the rits, black, red and green shales and slates of the Ordovician. he Ordovician grits contain not only fragments from the granitic nd gneissic masses, but also from sedimentary beds, limestones, ates and quartzites, which must have been somewhere above ater. The black Ordovician shales abound in graptolites and we their origin to organic matter. The red slates and shales, ith their high percentage of ferri coxide, and their proximity to he black shales, suggest the possible agency of decomposing rganisms in their formations, and that either on land or in the ea.

Sixth. Probably at the close of the Ordovician time the accumulated sediments gradually emerged in gentle folds. Under increasing pressure new mineral combinations were formed in the sediments; cleavage, foliation and grain were superinduced in the finer sediments.

Seventh. At some later time another movement occurred, resulting in various secondary structures, diagonal joints, slip cleavage, superinduced on slaty cleavage, quartz veins, minor faults and shear zones.

Eighth. The Cambro-Ordovician area between the Adirondacks and the Green Mountain highlands was then exposed to a long period of erosion from atmospheric agencies. Large areas of the Cambrian thus became denuded of their Ordovician sediments.

Ninth. Direct atmospheric erosion was interrupted, however, by the southward extension of the north polar ice cap which rounded, polished, furrowed and scratched the surface of every exposed slate ledge in the region.

Tenth. The retreat of the glacier left the surface covered with boulders and morainal material, which was redistributed by the great streams from the thawing ice.

Eleventh. A later depression of the Lake Champlain region, amounting to from 300–400 feet, let in the sea from the north which formed a bay extending as far south as Albany, and left sea beaches with marine shells above the lake.

Twelfth. The re-elevation of the region brought in the present conditions.''*

BUILDING AND ORNAMENTAL STONE.

LIMESTONE.

Naturally, the first quarries opened in the state were those in which building stone was sought. As soon as stone is quarried and drawn to the spot where it is to be used in building, there is need for mortar and this must be obtained from limestone. Hence the first quarries in any new country must be hose of the most conveniently located building stone, and of mestone if any is to be found. In this state nearly all the mestone is located in the western part and not far from Lake hamplain. To the eastward of this narrow strip the rocks of ie state are mostly, though not exclusively, schist, granite, neiss, quartzite, and other metamorphic rocks. This being ie case, while building stone is found in all parts of Vermont, me can be burned in few places except in the western portion f the state. East of the Green Mountains, lime has been urned at Whitingham, Plymouth, Townshend, Weathersfield, avendish, and other places. West of the mountains, it has een obtained at Highgate, Swanton, Colchester, Grand Isle, randon, Leicester Junction and elsewhere, and, of course, iroughout the marble border.

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* Dale l. c. p. 299.

Probably as old a quarry as any in Vermont, if not the old-st, is that at Fisk's on the southern end of Isle La Motte. his is in an almost black limestone containing few fossils, but ifficient to fix the age of the rock. Stromatocerium lamot-ense, Seely and Maclurea magna, Hall are most character-itic, though other species occur, and place the quarry in the wer Chazy. For more than a century stone has been taken ut at this point. The quarry is nowhere much below the level f the neighboring carriage road, which is only a little above ie level of the lake. By the aid of a tramway the quarried locks are easily taken to the dock on the shore of the lake. n addition to what was said of this quarry in the last report a w points may be noticed. The walls of the quarry are no-here very high, not more than twenty or at most, thirty feet. he area from which stone has been removed is large, I should iink not far from twenty acres.

Fleury's quarry, a short distance southeast of Fisk's, is the nly other quarry now worked on Isle La Motte, though there re several which are not worked. Until recently there have een no quarries of much importance on Grand Isle, but now iere are two on Phelps' Point which have been opened and are orked by the Rutland Canadian railroad, the stone being all used in the construction of the road. Both of these quarries furnish an abundance of good stone. The quarry which is located farthest to the east is remarkably thick bedded. Some of the blocks which had been thrown out of place by blasts were 15 or 16 feet thick. The beds are black, or dark gray and very sparsely fossiliferous, but a few Maclureas and Brachiopods and fragments of Asaphus were found. At the other quarry, which is just northeast of the north end of Providence Island, from which Grand Isle is separated at this point by only a very narrow bit of water, the bedding is thinner and the stone better for many purposes. At the time I visited the place blocks were being quarried and dressed for piers and abutments of bridges, etc. The stone at this quarry is much more fossiliferous than that at the larger one farther east. Some of the layers here were well filled with Maclurea and other Chazy species.

Probably the limestone quarries at Highgate and Swanton are among the oldest in the state. They have, at any rate, been worked since the early part of the century. Aside from certain minor quarries, those of importance are that at Highgate carried on by Mr. L. E. Felton and those of Messrs. J. P. Rich and W.P. Fonda at Swanton. All of these furnish the stone for extensive kilns in which lime is made. The limestone is what is generally known as the "dove." It is a hard, compact and very pure stone as the following analysis shows.

Analysis of Limestone from Swanton *:

Calcium oxide, CaO	55.83
Magnesium oxide, MgO	Trace
Iron and Aluminum oxides	.10
Silica, SiO	.40
Carbon Dioxide, CO	43.65
Total	99.98

The quarries are not deep, but as the illustrations show, the ledge of stone has been quarried away over a large surface without going down very far. Figure 6 shows a small part of the quarry carried on by Mr. Rich.

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*Mineral Resources of the U. S. 1898, p. 456.

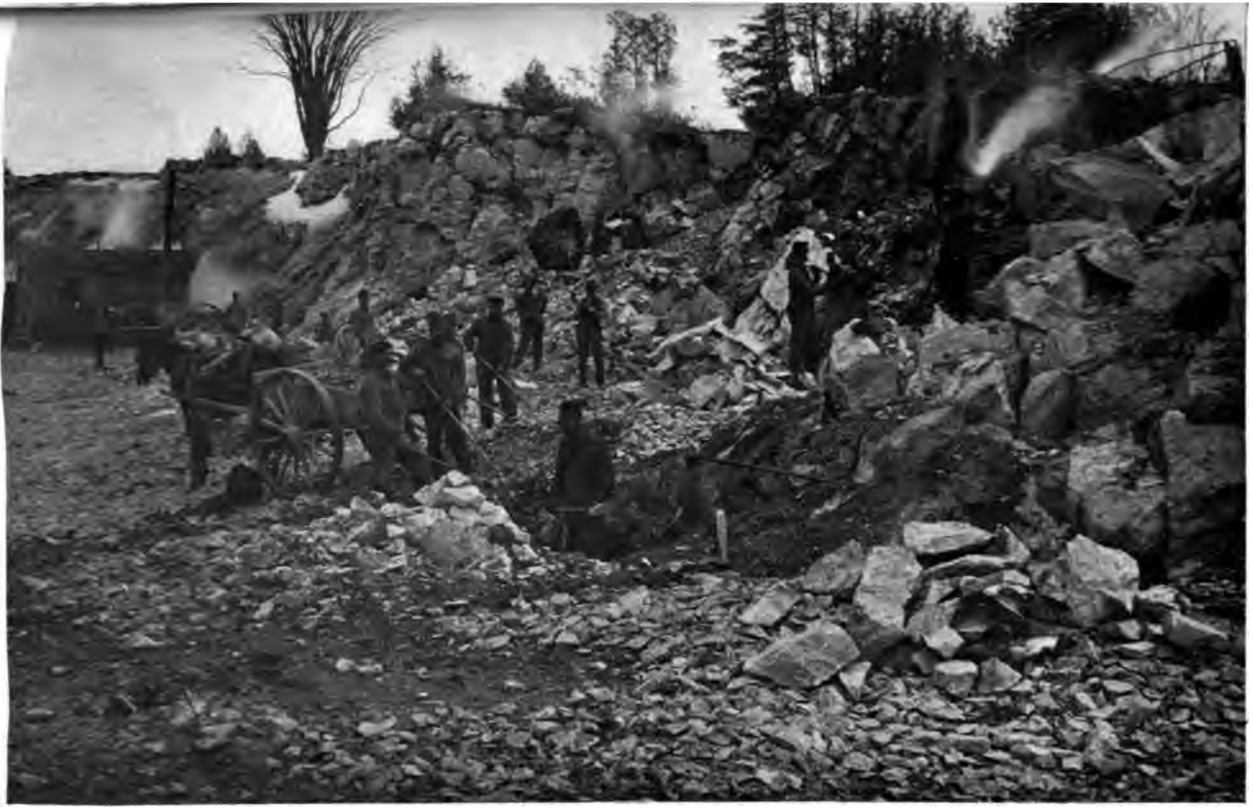

Figure 6. Limestone Quarry of J. P. Rich, Swanton.

The dove limestone makes a very delicately shaded marble and for a time in the early part of the century it was one of the most highly valued marbles in use in the state. In some of the best of the old houses especially in Northern Vermont, there are not only hearths, but finely wrought mantels of this marble and very elegant they are. It takes a good polish and finishes well in every respect. The Barney Company still use it in their trade and it produces a very pleasing effect when used in mosaic tiling with the colored marbles. There is, however, difficulty in getting large slabs which are free from flaws to which the stone seems to be very liable. For this reason it is not used as marble as extensively as it otherwise would be.

The dove limestone, though occurring in thick beds is remarkably wanting in fossils. Some of the exposures have been long and carefully examined with no results. On this account it is difficult to assign it to a definite geological period. I think, however, that they will, most of them at any rate, be finally placed in the Calciferous, probably the lower. What I believe to be of the same age as the Swanton dove limestone is found in what is locally known as the "Lime Kilns," a couple of miles or so northeast of Burlington. At this place a great deal of limestone has been quarried and burned to lime. Diligent search has revealed no fossils at this quarry, but on the farm of Mr. D. B. Griffin where the same formation crops out, perhaps a mile north of the quarry, well defined fossils have been found. The most clearly distinguishable of these are remarkably well preserved specimens of Billings' Pleurotomaria (Raphistoma) Canadenses Stromatocerium and other Calciferous species. It immediately overlies the Red Sandrock, which is Middle Cambrian, and as a rule lies to the east of this rock, though at Swanton there are considerable beds of the Winooski or Champlain Marble east of the limestone. The principal quarries of the Barney Company from which the Champlain Marble which is worked up in the mill is obtained, are in these beds and they are of the same age [illegible] the Red Sandrock.

The dove limestone produces a most excellent qualit lime. The following average of the analyses of four sample the Swanton lime show its quality.

Average of four analyses of Swanton lime :

Calcium oxide, CaO	98.
Magnesium oxide	.
Ferric oxide, Fe_2,O_3	Tr
Ferrous oxide, FeO	Tra
Carbon dioxide, CO_2	.;
Silica, SiO_2	Tra
Total	99.'

At Winooski Park, Colchester, some lime is burned by To and Catlin, but not so much business is done at this place as merly. There are two companies which burn lime at Leice Junction and several smaller kilns in other places. Accordin the report in *Mineral Industries of the U. S.*, Vermont, in 1 produced lime to the value of $178,750, but this must be an u estimate for, not taking into account several large firms which not sent in any report, those that did report in 1899 produced $225,000 worth of lime.

This industry appears to be subject to considerable fluc tions. In 1893 the production amounted to $400,000 ; in 189 $151,000; in 1896 to $147,000, while during the past year it has probably, in all the kilns, not less than $300,000. The Plymo limestone is a very peculiar brecciated stone which was form sawed and polished for marble, but in late years, the marble b ness not proving successful, it has been burned for lime. stone is said to be strongly magnesian and to make a strong, d ble, but not very white lime. The kilns used in the larger works are perpetual, that is, they can be used continuously, fire not being directly beneath the stone as in the old kilns, in a separate chamber at one side, from which the flame passe into the mass of limestone. By this arrangement the lime ca removed as formed without disturbing the fire and conversely fire can be replenished without interfering with the charge of st A row of such kilns is seen in Figure 8, which shows kiln Fonda's quarry.

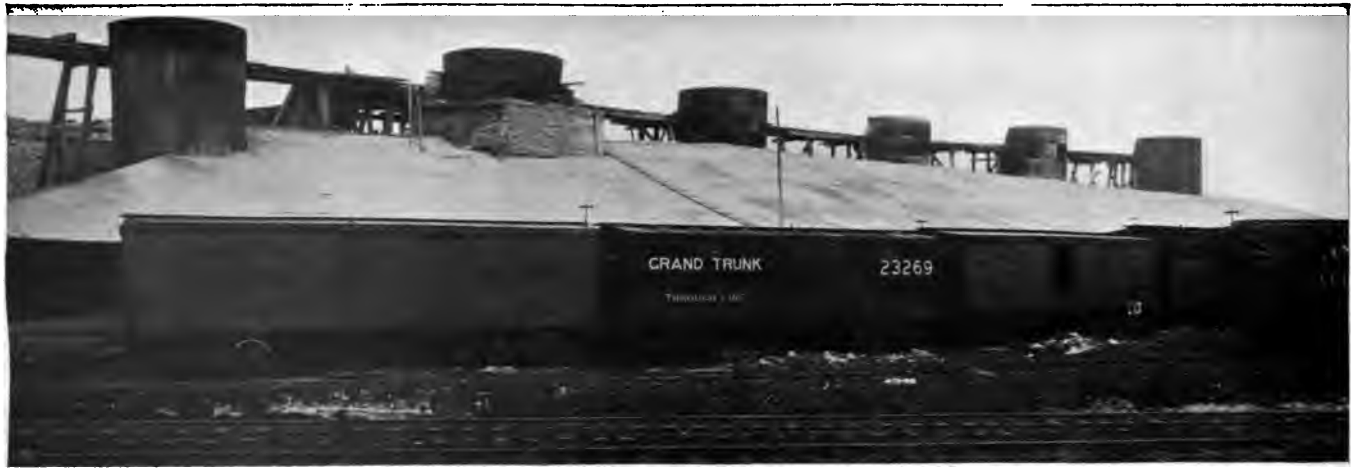

FIGURE 8. PERPETUAL KILNS AT THE WORKS OF W. B. FONDA, SWANTON.

The stone broken to a suitable size is thrown in at the top of the cylinder and renewed as often as necessary. The lime as formed drops below, where it can be removed from time to time.

MARBLE.

Since the country was sufficiently settled to need marble for ornamental or building purposes, Vermont has supplied the need more largely than any other state, or all others combined. Vermont marble is not only valued above other sorts in this country, but it is to some extent exported to foreign countries, even as far as India, China, Japan and Australia.

While the marble industry in this state has never had any such remarkable and rapid development as has the granite business, yet it has for nearly a hundred years been steadily growing and is so established that it seems quite improbable that anything can permanently or seriously check its growth.

It is indeed true that in some parts of the marble belt of the state, there seems to be a bad showing for the business. There are abandoned quarries, tumble down mills, rusting machinery in some localities, and the sight of such things is not encouraging, but this is by no means the universal condition of the business. Like all industries, this has had its ups and downs. The use of marble increases or decreases with the prosperity of the country. When money is abundant, much marble is used in the adornment of buildings, while in stringent times, plainer and cheaper materials are used.

According to the Report of the United States Geological Survey, Vermont, in 1898, produced marble valued at $2,067,938, which is nearly two-thirds of all produced in the United States. The largest sales on record were made in 1872, when they amounted to $2,275,000. During the years immediately following 1872, the sales fell quite perceptibly, until 1896 they were only $1,101,000. Since then they have steadily increased and the report comes this year, 1900, from all the companies producing marble, that the sales are increasing considerably.

In 1898, Georgia and Tennessee exceeded Vermont in the quantity of marble sold in the rough, but this state sold more cut stone used in building than any other state, and of the marble used in monuments, Vermont furnished nearly ten times as much as any other state, and over six times as much as all others combined.

Vermont marble seems to be increasingly in demand for building. As we have seen, it has always been more in demand for ornamental purposes than any other marble, but the stone from several other states has been used in larger quantities for outside building. In 1897, however, the sales of Vermont marble for this purpose were nearly double those of the previous year, that is, they grew from $207,319 in 1896, to $402,912 in 1897, and $441,439 in 1898. This is an important matter because the coarser grades of stone which can not be used in monumental work, are often excellent for building. Much that is produced in some quarries is waste material if only monumental material can be sold, but if this can be utilized as building stone it is a great gain. Many quarries which cannot be profitably worked for monumental stock alone, may be worked to advantage if all the stock obtained can be marketed, if not for monuments, for building or some other purpose.

Figures 9, 10 and 11, illustrate the use of the Rutland marble in buildings. Figure 9 shows a church in New York City, in which the darkest Pittsford, the "Mountain Dark," is used, in part of the building finished over the whole surface, in part rock faced. Figure 10 is a library building in Troy, N. Y., in which the dressed white marble is used. Figure 11 is a church in which dark rock faced stone is very effectively used.

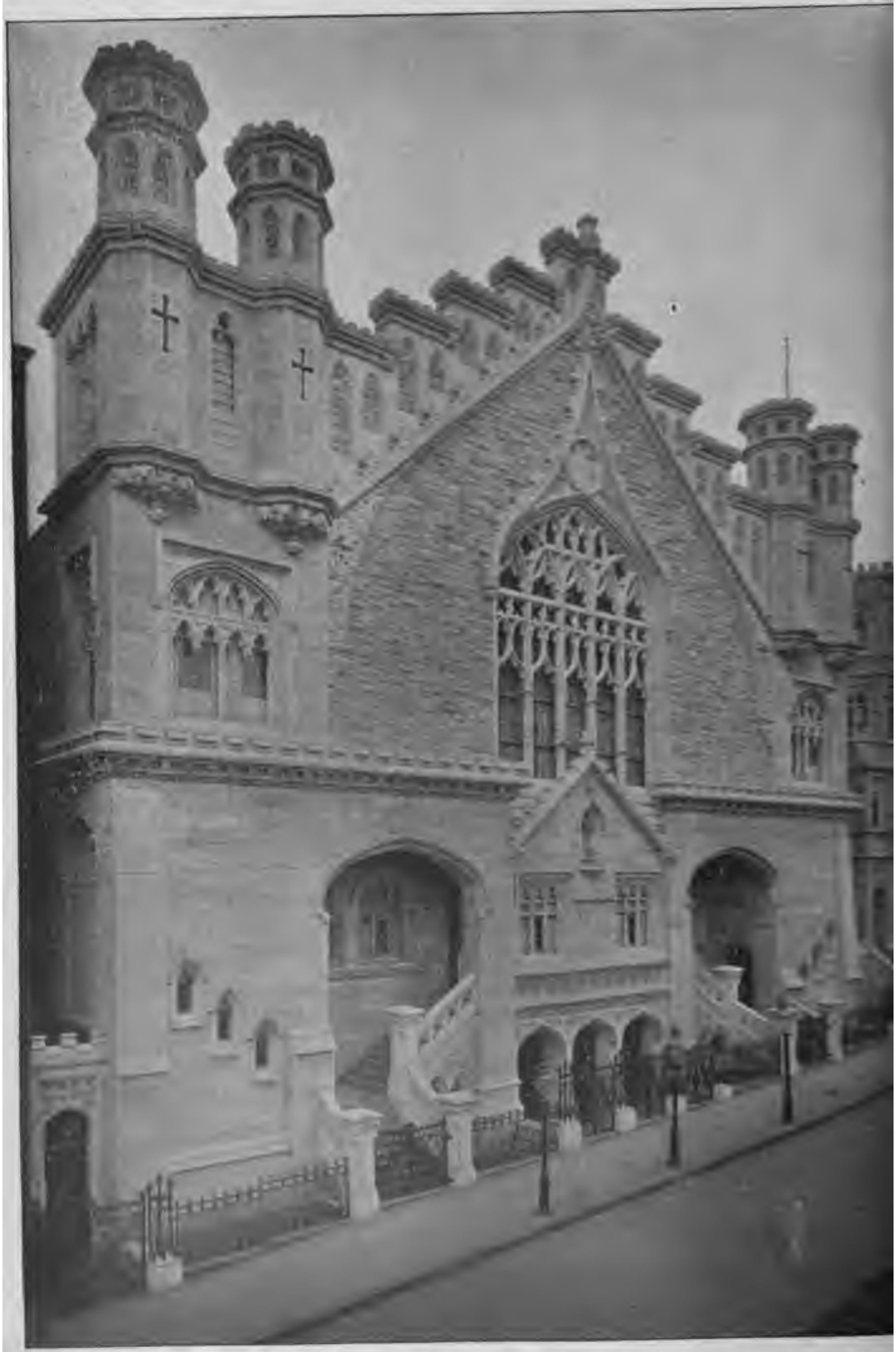

FIGURE 9. LARGE CHURCH OF DARK MARBLE. The stone is part of it full hammered, part rock-faced. New York City.

The location of the two great industries, the slate and the marble is very interesting, situated as they are each in a long narrow area, one on the west side and the other on the east side of the Taconic range. By far the larger part of the quarries both of marble and slate, is in a single county, Rutland, and the more important quarries from which the stone comes are included within a small area. The Taconic hills form a complete barrier between the marbles and the slates, no marble being found on the west side of the hills and no slate on the east. Geologically, the marbles are of the same age as the red slate of New York, or not very far from it, while, as we have seen, the Vermont slates are of an older formation. The marble belt reaches farther north than the slate, but the southern limit of the two is, in Vermont, about the same. The southern limit of the marble is at Dorset, that of the slate at Rupert. The marble area is, as a whole, about twice as long from north to south as the slate and it is also wider from east to west. In what is known as the Ripley quarry at West Rutland, near the bottom there is a layer, possibly more than one, in which when the stone, which is a bluish gray marble, is sawn and polished numerous sections of Maclurea appear. To all appearance this is Maclurea magna and fixes the age of the stone as Chazy. So far as I know, these fossils from the Ripley quarry are the only ones that have been found in the true marble, but, as noticed in the last Report, the age of the Rutland marbles has been pretty well settled by the investigations of Rev. A. Wing.*

Interesting and valuable discussions of the geology of the region about Dorset and Rutland may be found in the following works:

BULLETIN GEOLOGICAL SOCIETY OF AMERICA, Vol. II, pp. 331–338. *On the Lower Cambrian age of the Stockbridge limestone of Rutland*, J. E. Wolff. BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA, Vol. III, p. 514. *On the Structure and age of the Stockbridge limestone in the Vermont Valley*, T. N. Dale. UNITED STATES GEOLOGICAL SURVEY, FOURTEENTH ANNUAL

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*See Am. Jour. Science and Arts, Third Series, Vol. XIII, pp. 332 and 405, also Vol. XIV, p. 36.

REPORT, p. 525. *On the Structure of the ridge between the Taconic and Green Mountain Ranges in Vermont*, T. N. Dale.

As would be expected, there is some difference in the shape and size of different quarries since these characters are largely determined by that of the marble bed which is being quarried out. Most of the quarries are deep pits of a quadrangular form, a few are open in part, but the quarrying has followed the beds of marble into the surrounding rock, thus making a tunnel. Freedley's quarry on Dorset Mountain, described in the last Report, and the first, or covered quarry, of the West Rutland series are examples of this kind. Figure 12 shows very well the inside of a typical quarry. In this figure the common method of taking out the marble is readily seen. After the surface soil and whatever

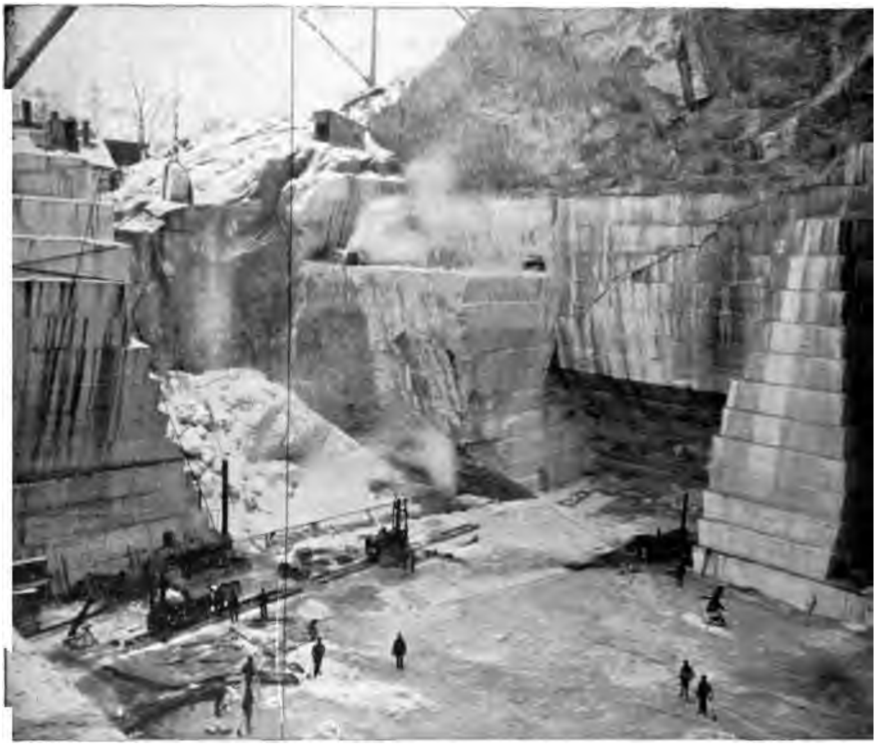


FIGURE 12. THE INSIDE OF A TYPICAL MARBLE QUARRY.

worthless stone there may be, is removed, and thus a large surface of marble worth saving is exposed, a channelling machine is put at work on the floor of marble. The most commonly used machine in the Vermont quarries is the Wardwell. This machine, Figure 13, is complete in itself, being a steam engine and stone cutting machine combined. After the quarry

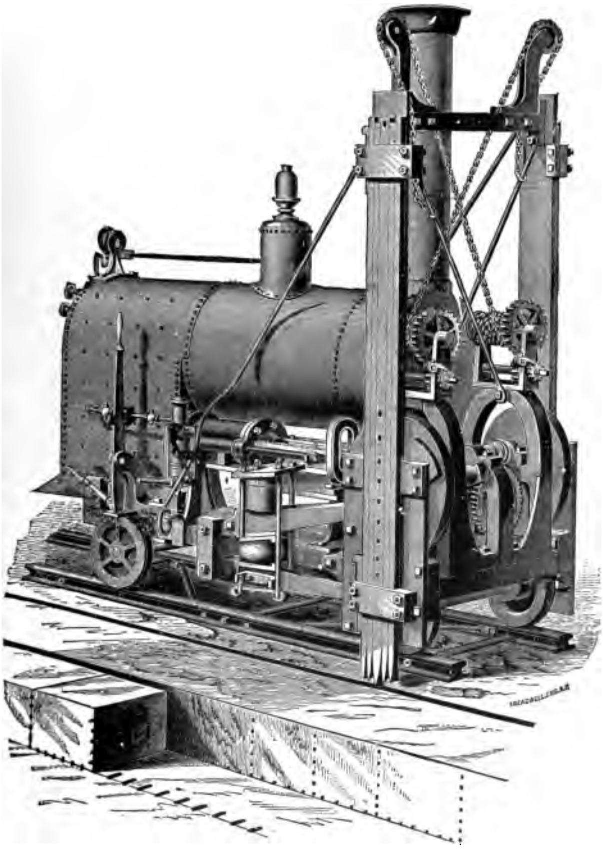


FIGURE 13. WARDWELL CHANNELLING MACHINE, STEAM STONE CUTTER COMPANY, RUTLAND.

has been cleared, as just indicated, a track is laid on the surface of the marble bed and on this the channelling machine runs back and forth, the gang of hard steel chisels, seen in the illustration on each side of the front at the right of the picture, are continually moved up and down. In this way a channel is cut in the solid bed of the quarry to such depth as the layer to be cut out indicates, it may be two feet, it may be ten. When the channel is cut through the layer of marble, the machine is moved to one side and another begun. Some machines cut only a single channel, others, like that figured, cut a channel on each side. After the channels are cut, another and smaller machine, a sort of steam drill called a gadder is brought into use and by this a series of holes, seen in the foreground of the illustration, is drilled, then by means of wedges the blocks are detached without blasting.

After one layer of marble has been removed, a second is taken out in the same manner and so on as long as good marble is found. In Figure 12 the lines along the sides of the quarry show where the successive layers were taken. Because of this method of quarrying, the interior of most marble quarries presents a much less ragged and rough appearance than do most stone quarries. In many of the quarries, blocks of almost any desired dimensions can be gotten out. I saw piled up beside one of the West Rutland quarries, nine blocks that measured 20x3x2 feet each and larger than this have been quarried. Still the common size fcr ordinary use is 6x4x4 feet.

The variety in shade, from very dark to pure white, which can be found in a single quarry, more fully described in the last Report, enables the producers to put stone suited to almost every building upon the market. After the stone is cut into blocks in the manner indicated, the blocks are taken to the mill and sawed. Marble was sawed by the ancients, no one knows how long ago, by the aid of sand and a strip of soft iron ; it was also cut in the same manner in Europe many years ago, but in this country, so far as it appears, the first stone sawed in this way was in Middlebury in 1804. Before this, as noticed in a letter quoted beyond, all slabs were laboriously worked out with hammer and chisel. Even with the latest appliances for sawing stone, the process is tedious and to the general observer, uninteresting. Figure 14 shows what is called a "gang" of saws.

Each saw is a strip of soft iron, about an eighth of an inch thick, with no teeth, simply a smoooth edge. Several of these bands, varying with the size of the block to be sawed, and the number of slabs to be obtained, are fastened into an iron frame which can be raised or lowered. As many as sixty saws are sometimes used in a single frame. When a block is to be sawed it is placed beneath the raised frame which is then let down upon it. The gang is then moved back and forth, over the block, sand and water being abundantly supplied. Back and forth, back and forth, day and night the saws are moved unceasingly, the frame dropping a little with every stroke until, as in the illustration, the block is cut through. In some of the harder marbles an amount of sand equal in weight to that of the stone is used. In ordinary marble, the rate of cutting is about

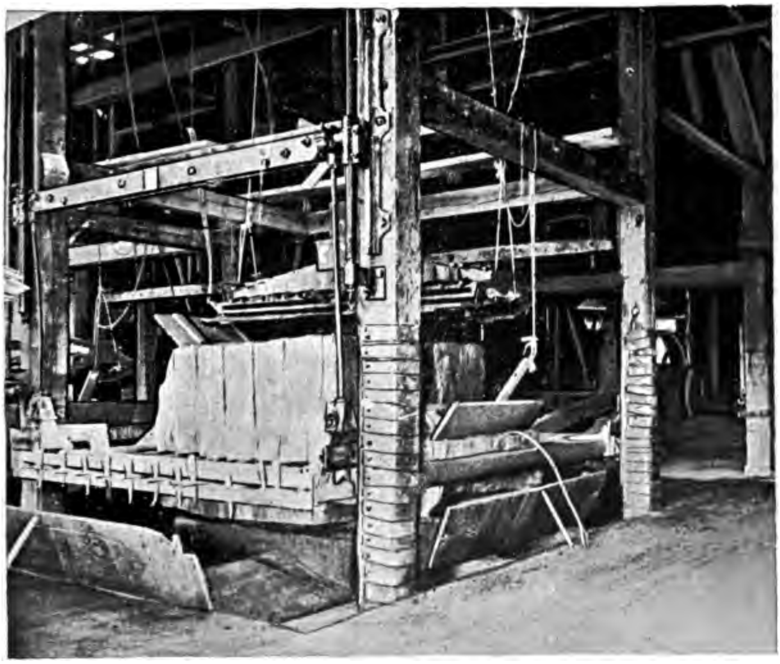


FIGURE 14. A GANG OF SAWS CUTTING A BLOCK OF MARBLE. From the Vermont Marble Company.

an inch and a half or two inches an hour, but in the hard marbles it is much less. The most common size of slab is six feet by four, but there is a gang at one of the mills of the Vermont Marble Co. which will saw slabs six and a half feet long by ten feet wide. In the marble mills of the state there must be not less than four hundred gangs of saws now at work.

After being sawed into slabs, the marble is resawed into such sized pieces as may be needed and then smoothed and polished if for ornamental work. These processes, until recently done by hand, are now done much more rapidly by machinery. Indeed it is most interesting to notice as one passes through one of the modern mills, how all the work is done by machinery. The shaping of columns, moulding of edges, etc., are now done in stone in about the same manner as they are in wood. Figure 15 shows how great columns are turned out of huge blocks of

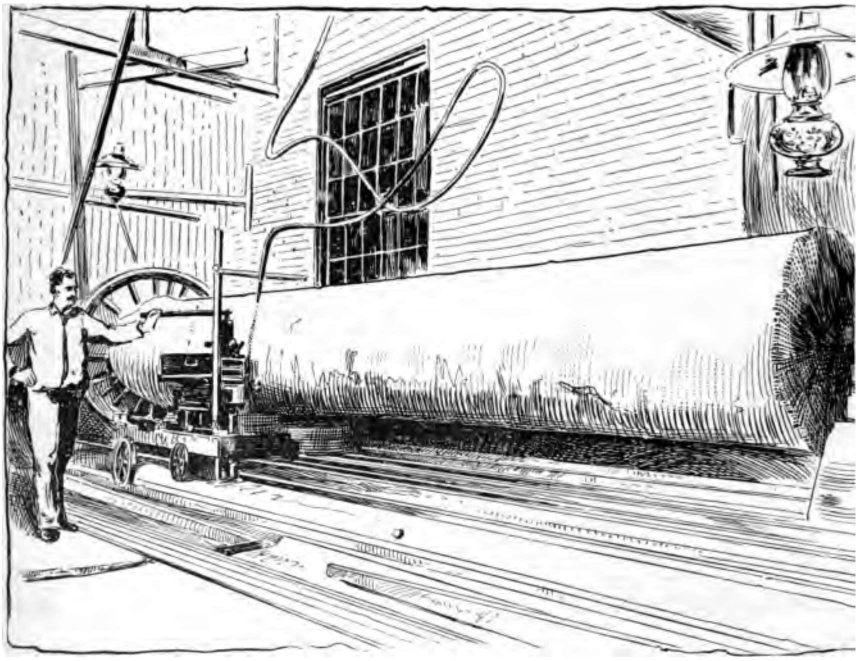


FIGURE 15. TURNING A COLUMN OF MARBLE ON A LATHE.

stone. The column shown was nearly twenty-four feet long and three feet in diameter.

There has been some difference of opinion as to the location of the first marble quarry in the state. In my last Report I stated that the first quarry was opened in Dorset in 1785 on the farm of Reuben Bloomer.

Mr. Geo. E. Royce of Rutland, however, writes me as follows: "I would say that without any doubt, the first marble quarry opened in Vermont was on the property now owned by the True Blue Marble Company and was situated by the side of, and underneath, the present mill of the company and according to the town records of Rutland, was opened in 1785 and was worked continuously in a small way for about fifty years. The record shows that from the beginning it was described as a 'Stone quarry, so called Marble' and in 1795 it was sold for £400, about $2,000. In 1812 our member of Congress, Ezra Meech, took a contract to supply for a Government building in Charlestown, S. C., a quantity of it and it was hauled with wagons to Troy and shipped by water to New York and to Charleston, by vessel. Almost all of the headstones standing in the cemeteries from Bennington to Burlington, dating from 1785 to 1830, came from this quarry and are almost all in good condition. They were worked before sawing was done and tooled by hand. The quarry was 150 feet long and 125 feet wide and 16 feet deep. It was practically surface marble and in modern times, the marble to the depth of from 15 to 20 feet is either dumped or only used in work that is not to be finished or polished and is not put into monumental work at all except perhaps, sometimes, into a bottom base."

Whether the quarry of which Mr. Royce speaks or that mentioned by Professor Seely in the Marble Border of Western New England, which is at Dorset and is said to have been opened in the same year, 1785, is older, it may not be easy to determine.

In the early days of the marble industry, and until quite recently, only the lighter varieties of marble were in much de-

PHOTO-ENG. CO. N.Y.

mand for interior or any ornamental use, but of late the darker shades have come into favor. Certainly anyone who may see the richness and elegance of such marble as the True Blue of West Rutland, or The Mountain Dark of Pittsford, can well rejoice at the increased use of the dark marbles in all suitable places.

The expense of opening and working a marble quarry is large, hence only a firm with considerable capital can hope to succeed in such an enterprise. For this reason most of the marble sent from Vermont and therefore most of that used in the country, is produced by a few large companies.

Working in the marble belt of which Rutland is the business center, there are the following companies now engaged in business: *Dorset Mountain Marble Company*, South Dorset ; *J. K. Freedly and Sons*, East Dorset ; *Columbian Marble Quarrying Company*, Rutland, Proctor, West Rutland, Bristol, Burlington ; *True Blue Marble Company*, West Rutland, Pittsford ; *Vermont Marble Company*, Rutland, West Rutland, Proctor, Pittsford ; *Brandon Italian Marble Company*, Brandon, Middlebury ; *Bardillo Marble Company*, Brandon ; *Corona Marble Company*, Brandon. These companies report a combined capital amounting to $3.700,0co. They employ nearly 2,500 men, pay annually in wages $1,000,000 and last year produced or sold marble to the value of $2,180,000. As has been already mentioned, nearly all of the above companies report increasing business.

The quarries on Dorset Mountain, of which the most important is that of Freedly and Sons, were described in my last report and I have no further information to give concerning them as there have been, so far as I know, no very great changes in their work since that report was published. Probably the largest marble company anywhere is the Vermont Marble Company, the principal office of which is at Proctor. This Company report that they are at present working all of their quarries. These include all those at West Rutland, except the True Blue, and one just opened by the Columbian Company; the quarries in and about Proctor except the Columbian, and,by lease,the Hol-

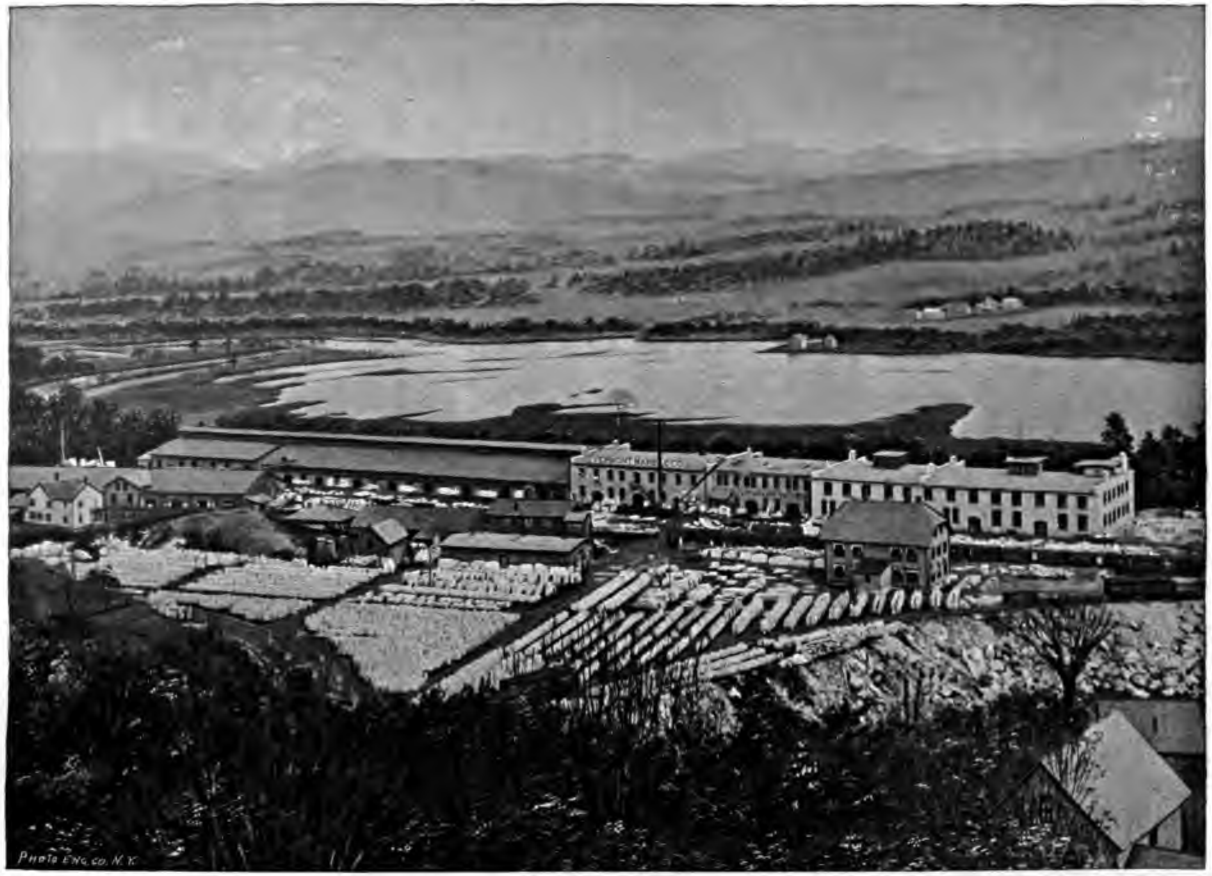


PHOTO ENG. CO. N.Y.

lister quarry at Pittsford. The Company own and operate The Clarendon and Pittsford and the Pittsford and Rutland Railroads which are together fifteen miles long. The mills are very large and are located at Proctor, Center Rutland and West Rutland. Figure 17 shows a general view of the works of this Company at Proctor. Last year this Company did some work on deposits of colored marble at Monkton and some very delicately and beautifully shaded stone was worked up, but the enterprise has not been continued. Further information respecting the quarries and marble worked by this Company may be found in my Report of 1898.

The True Blue Marble Company has for eighteen years worked the most northerly of the West Rutland quarries. This quarry is in a large bed of dark, richly veined and clouded marble of a very compact and even texture, which is also worked in the adjoining Esperanza quarry of the Vermont Marble Company, just south. The True Blue quarry is an opening three hundred feet long by one hundred feet wide. The quarry is not yet what would be called a deep quarry, being nowhere, I should judge, more than fifty or sixty feet deep. The same Company own four quarries in Pittsford which supply both dark and light marble. The Company reports that they have recently bought large marble properties in Pittsford which cover over a mile in length of continuous marble deposits. "On the Sutherland Falls vein, two hundred feet thick; Florence vein, six hundred feet thick; West Rutland vein, two hundred feet thick, and have bought the railroad running to them from the Rutland Road. These purchases include what is known as the Old Central Vermont quarry property of a hundred and sixty-five acres, the Newberry property of one hundred and eight acres, besides several smaller properties which, together, make a total of three hundred and eighteen acres. Altogether, the Company own six hundred acres of quarry land."

The Columbian Marble Quarrying Company is working a large quarry at Pittsford, a few rods south of the well-known Sutherland Falls quarry of the Vermont Marble Company. This Company has also quarries at West Rutland and Bristol. Besides blue and white marble, they quarry colored marble. North of the quarries mentioned at Florence there are no worked quarries south of that of the Brandon Italian Marble Company. This quarry, which is located near the railroad a short distance south of the station,is large and deep. It has been worked a good many years. The quarry is of peculiar shape as it is very much longer and narrower than any other quarry which I have seen. The bed of marble runs approximately north and south and is quite deep. The stone is light clouded and finely bedded. The large mill of this Company was burned in 1898 and the new one which takes its place is located at Middlebury where the water power of Otter Creek is used. The work of this Company was necessarily considerably hindered by the loss of their mill and the delay in getting settled in the new one. Yet they report good sales and the prospect of better, now that they can better fill orders.

About two miles southwest of Brandon village is the Bardillo quarry and mill. Both of these are in active operation. The marble at this quarry is, on the whole, dark and is not like any other that I have seen in its abundant veining. It is a very handsome stone.

North of Brandon, the Corona Marble Company have three quarries from which white and blue marbles are obtained. The Company has also a mill. Both quarries and mill are now leased.

The siliceous limestone, which has been to some extent quarried in the town of Washington,is still worked, though in the case of most of the quarries, rather irregularly. This stone was so fully described in the last Report, that little more need be said here. It is unfortunate that it sometimes goes on the market as "granite" for it has no claim to the name, being in no sense granite, but a well defined limestone and it should always be considered as a marble in trade. In general the polished stone is a very pretty bluish gray, strongly and numerously veined with dark gray or black. The stone is fine grained, takes a fine polish and must be very durable. The main difficulty in selling it to advantage is found in the distance of the localities where it is quarried from any railroad. Larger capital than appears to be available at present is needed to develop the beds properly. The supply seems to be ample.

The deposits of this stone are well deserving of investigation for they furnish a very distinct and very attractive variety of marble. The principal quarry and the only mill in Washington is that of the Warner Granite Company. The quarry is now thirty-two rods wide and seventy rods long. The mill is not large, but is equipped with some good machinery for cutting and polishing the marble.

The variegated marbles of Swanton and Colchester are not only of older geological formation, but very different in every way from the lighter Rutland marbles. There are two firms now producing the Champlain Marbles, that which has been so many years established, The Barney Marble Company, and the Champlain Marble Company, both of Swanton.

The stone is a siliceous dolomite and different layers afford most pleasing combinations of many shades of red mingled with more or less of clear white. Olive and green veins also occur in some of the beds.

The great difficulty in profitably working the Champlain, also known as the Winooski and Swanton Marbles, consists in the hardness of the stone, which is much greater than that of other marbles. This same quality, however, causes it to take a more brilliant and durable polish. Unfortunately it adds very much to the cost of sawing, cutting and polishing and of course to the price at which it can be furnished.

Nevertheless for many years tile and polished work have been produced at Swanton, first by George Barney and after by his successors, the Barney Marble Company. This marble may be seen in many of the finest and most costly buildings all over the country. I regret that it has not been possible to give in this connection colored plates of some of the varieties of these Champlain Marbles. Anyone who is sufficiently interested to take the trouble to look them up, may find very good representations of the Champlain, and also of some of the Rutland marbles, in Volume *10*, *United States Census Report*, 1880, Plates 30, 31, 33, 34, 35, 36, 37.

The Champlain Marble Company has within a year or two opened quarries near Swanton Junction, where stone similar to that in the Barney quarries at Swanton is found in abundance. There is also a small quarry of this stone near Burlington, which has been recently opened. The large quarry and mill at Malletts Bay have not been in operation for years.

In the early days of the marble industry at Swanton the harder variegated marbles were neglected and at first only the dove limestone, already mentioned as that used for the manufacture of lime, was sawed and polished. This was in 1812. It was used for hearths and to some extent for mantels. Some years later the black limestone from Fisk's Quarry on Isle laMotte largely displaced the Swanton "Dove." Like its predecessor, this was used in hearths, mantels and tiles. It is said that the first black marble tiles ever made in America were those furnished by George Barney in 1848 for a large building in New York. Mr. Barney was also probably first to put the Champlain marble on the market.

The Barney Company also own and work a quarry of Serpentine, Verde Antique. The stone quarried at Roxbury, is taken to Swanton to be worked up. It is a most elegant stone, though, because of the difficulty of working it, very costly.

Serpentine is found in many localities in the state, but only two quarries have ever been worked. The first of these was opened at Cavendish over sixty years ago, but the expense of getting out good blocks and conveying them to market was too great and the enterprise was abandoned.

The Roxbury quarry has had a similar experience, having been worked for a few years and then for many years left idle, no work having been done there since 1858. Two or three years ago the Barney Company took hold of the old quarry and have taken out some magnificent blocks. The stone is elegantly veined in various shades of green intermingled with black and white. Perhaps as good specimens of this Verde Antique as any are to be seen in the water fonts in the South Union Station in Boston. This stone is composed of silica, magnesia, ferrous oxide, lime carbonate and water in varying proportions in different samples. In general it is a magnesian silicate.

GRANITE.

In the last Report I called attention to the wonderful progress made by the granite industry of Vermont since 1880. This business is still increasing and seems likely to grow on indefinitely. From nearly all of the granite quarries comes the report that sales were never so large as at present, and that they are constantly becoming larger. During the past two years granite has been quarried at Barre, Williamstown, Woodbury, Dummerston, Kirby, South Calais,Ricker's Mills, Beebe Plain. Different varieties of granite are obtained in different localities, and indeed often in the same quarry. These varieties are mainly produced by different arrangement of the ingredients, quartz, feldspar and mica, which compose the stone. As these are in fine or coarse particles, the texture of the granite is fine or coarse, as the dark mica prevails rather than the lighter quartz or feldspar, the granite is dark. All known shades of gray granite are found in the state, but nowhere has red granite been found. Much of the Vermont granite is fine grained, compact, strong and very even in color and texture.

The supply is practically unlimited. Besides the great beds at Barre and Woodbury and Dummerston, and the smaller beds quarried here and there over the state, there are great areas as yet wholly untouched. Vermont has granite of the best quality sufficient to supply the world for many years. Hitherto Vermont has taken precedence of all other states in the production of marble and now within ten years,she has become one of the great and promises to be in the near future the greatest granite center in the world, if not so already. According to the official returns at Washington, Massachusetts produced somewhat more granite in

1898. In the finer sorts of granite such as is used in monuments and the like, Vermont leads, having sold in 1898, $416,000 worth, or more than twice the quantity sold by any other state. This is a strong proof of the superiority of the Vermont granite. And it should be added that I have good reason to believe that the above amount is far below the truth as will be seen later. Vermont also sells more granite in the rough to be wrought elsewhere than any other state, but the sales of granite cut for building and broken into paving blocks are greater in several states. Very little Vermont granite goes into paving stones.

The demand for Vermont granite for the finer grades of work in which this stone is used, is plainly increasing rapidly. Some companies report an increase of thirty per cent annually for the past three or four years. Others report a less increase, but yet one that is very gratifying. Men who are in position to know, estimate the average increase in the business of all the Barre companies taken together, as not less than twenty per cent for 1899 and a similar increase is probably true of Woodbury and Hardwick. It is possible that the forthcoming Census Reports will give more complete and definite figures than I have been able to obtain, but I have not found it possible to get at the exact figures in all cases. Still I have statements from most of the larger firms and the statements given may be considered at least fairly correct. It may be noticed in passing, that men in the granite region, especially if they are interested in the prosperity of the industry, invariably estimate the value of the granite and of the quarries at too great a figure. This is not by any means necessarily intentional, but the interest which they have in the business, I mean general interest, in many cases it is not pecuniary, leads them to over estimate the extent of the business. I speak of this because I have many times found it to be true that men enthusiastic in the development of a business, though intending to give entirely accurate statements, find it almost impossible to do so. This is especially true in the present instance, for I find a wide discrepancy between the estimates which the granite men give in answer to inquiries and the reports which have come from various companies in response to blanks which were sent out. The most accurate figures should be those given in the volume of the United States Geological Survey on MINERAL RESOURCES and undoubtedly these are intended to be complete and correct, but I have in course of my investigations found reason to doubt some of them.

According to MINERAL RESOURCES for 1898–99, the last published, the total granite production of Vermont in 1898, amounted to $1,084,218. I think, however, that this is decidedly too small a sum. For several years the wages paid in Barre, leaving out all other quarries in the state, have amounted to more than the sum given as the value of the whole output, and anyone who is conversant with the business at Barre and the other granite centers knows that all, or the greater part of all, these mills and quarries are not being carried on at a loss as must be the case, of course, if the output is less than the cost of getting it. During 1899, and especially during 1900, more quarries have been in operation and the finishing works more busy than ever before. So far as I can get at accurate figures there are employed in the quarries and finishing works in the state not less than three thousand men. In Barre there are now on the rolls of granite cutters, not less than fifteen hundred names and in addition to these are polishers, carpenters, teamsters, etc., who together must materially add to the number of workmen, and at the quarries there are from eight hundred to a thousand more. At Woodbury, Hardwick, Dummerston and a few other places there cannot be fewer than five hundred more. Now it is evident that enough granite must be sold to pay this army of laborers. From all this it would appear that $1,500,000 is a very moderate estimate of the wages paid to the different classes of laborers in the granite works.

While my efforts to obtain figures which I could report as certainly accurate have not been wholly successful, I may yet report that it seems to me very probable that the total value of the granite produced in the state in 1900, is not less than $2,500,000. Some of those who are acquainted with the business of

Barre, estimate the amount produced in those quarries and mills as much greater than the above sum indicates and none of the quarry owners in Barre whom I asked to give the value of the stone sold in that place in 1900, put it as low as given above for the state.

Taking the figures given in the Report named, we find that the total product was divided as follows and, whether we accept the figures as a whole as accurate or not, it is interesting to note the proportions of the sales of granite in its different conditions.

Sold in the rough	$513,634
Cut for building	113,922
Value of monuments sold	416.878
Paving blocks	4,446
Crushed stone for roads	5,204
Curbing	12,134
Total	$1,084,218

If this table is to be trusted, it appears that about half of the granite quarried is sold in the rough, or much more than half in quantity, for the value of the rough block is, of course, far less than that of the same or a similar block which has been cut. I very much doubt, however, if it is at all true that the value of the stone sold in the rough is more than that of the monuments, etc., sold.

Nor do I believe that the army of cutters mentioned previously, are occupied in working up no larger amount of stone than that given. Certainly the Vermont granite workers are an exceptionally cheerful set of men if they are doing a losing business, as must be true if the above figures are even approximately correct.

The granite business is far less concentrated than is either the slate or marble. That is, the number of companies engaged in quarrying and working is greater, the works are scattered over a greater area and, as a consequence of this, the capital invested is more widely distributed. Mineralogically, the Vermont granites, so far as they have been examined, are largely muscovite granites, though biotite granites are not uncommon. The following analysis taken from the Twentieth Report of the United States Geological Survey, may be of interest to some of my readers.

Silica, SiO_2	69.56
Ferric Oxide, Fe_2O_3	2.65
Alumina, AL_2O_3	15.38
Manganese	Trace
Lime, CaO	1.76
Magnesia, MgO	Trace
Sodium Oxide, Na_2O	5.38
Potassium Oxide, K_2O	4.31
Loss on ignition, CO_2, moisture	1.02
Total	100.00

Figure 18, is a view of a part of Barre and in the foreground, some of the granite "sheds" where the rough stone brought from the quarries is cut and polished.

Vermonters need not be told that the greatest granite interests of the state are those at Barre. From the country village of twenty years ago Barre has grown into a most thriving and active city. It is preeminently a granite city, for this is the one all controlling interest. There is probably no place anywhere in the world where so large quarrying or stone cutting operations are carried on within an eqeal area. Barre is not only the principal granite center of the United States, but I think of the world, and it is rapidly becoming greater. Within a radius of a very few miles there are, in and about this place, according to the most accurate reports that I can obtain, fifteen hundred men employed as cutters and polishers, eight hundred or more in the quarries, besides blacksmiths, tool sharpeners, teamsters and other workmen, more or less directly connected with the business. It is easily seen that such an army of workmen with their families, must be an important part of the population of the place and con-

tribute very largely to its general business. It is also important to remember that all this increase of wealth and population has come to the state solely through the development of the formerly valueless granite ledges. Nothing of the slightest value in its original condition has been taken out of the state. This granite is of little or no value in its natural bed. The value consists almost wholly in the labor expended in getting it out and dressing it. Hence the gain to the state is wholly gain, and a great gain it has been already, and no one can visit Barre, its granite mills, sheds and quarries without carrying away the strong conviction that the end is by no means reached, but that the future will see yet greater things.

While the cutting, finishing, etc., are mostly done in the mills, or "sheds" at Barre, the quarries are all some four miles east of the town, at Graniteville, Williamstown and East Barre. Figure 19 is a very good view of one of the larger quarries.

How many quarries are now in operation at this locality, I do not know. It is estimated by the quarry owners that there are nearly a hundred, large and small. Most of the stone, however, comes from a much smaller number. About twenty companies supply the larger part of the Barre granite. Most of these companies, however, work several quarries. The quarries are none of them very deep, some are eminently surface quarries. The stone can be used from the start in the ledge so that the expense of opening a granite quarry is much less than that of starting a marble quarry. In the latter case, a large amount of surface stone must be gotten out and dumped before good stock can be obtained, and, of course, this involves no small expense before anything can be realized from the sale of stone. As a rule, which, however, has exceptions, the upper layers of granite are lighter than those farther down.

At Graniteville, the quarries extend along a ridge in a northerly and southerly direction almost continuously for about two miles, the width of the worked area being about half a mile. The quarries vary greatly in size and to a less degree in character. Some cover only a small area, others five, eight, or even

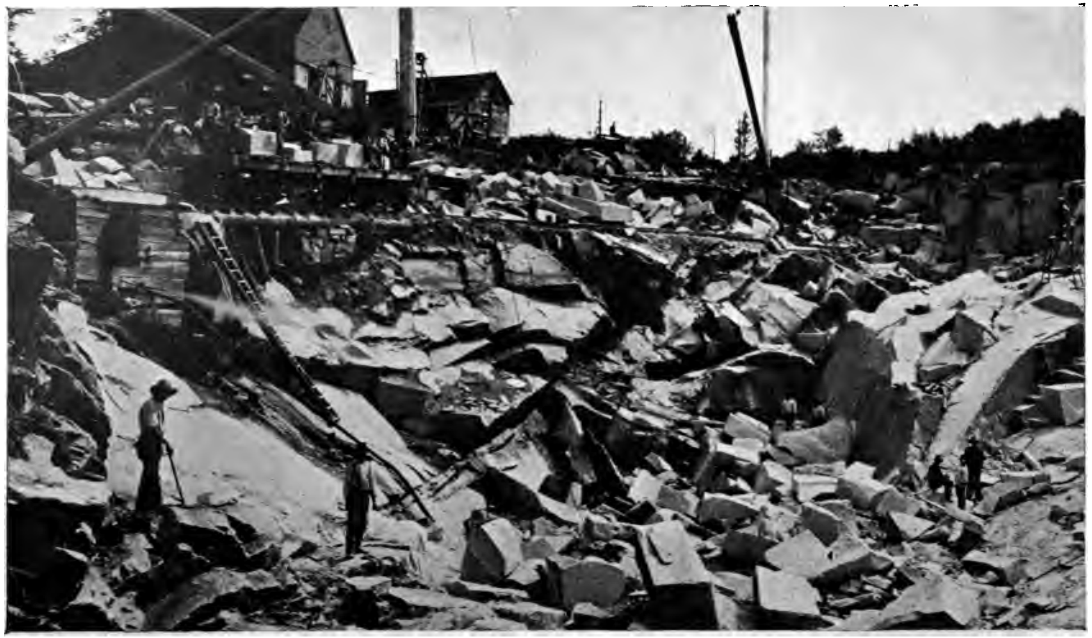


Figure 19. Granite Quarry of Wells, Lamson & Co.

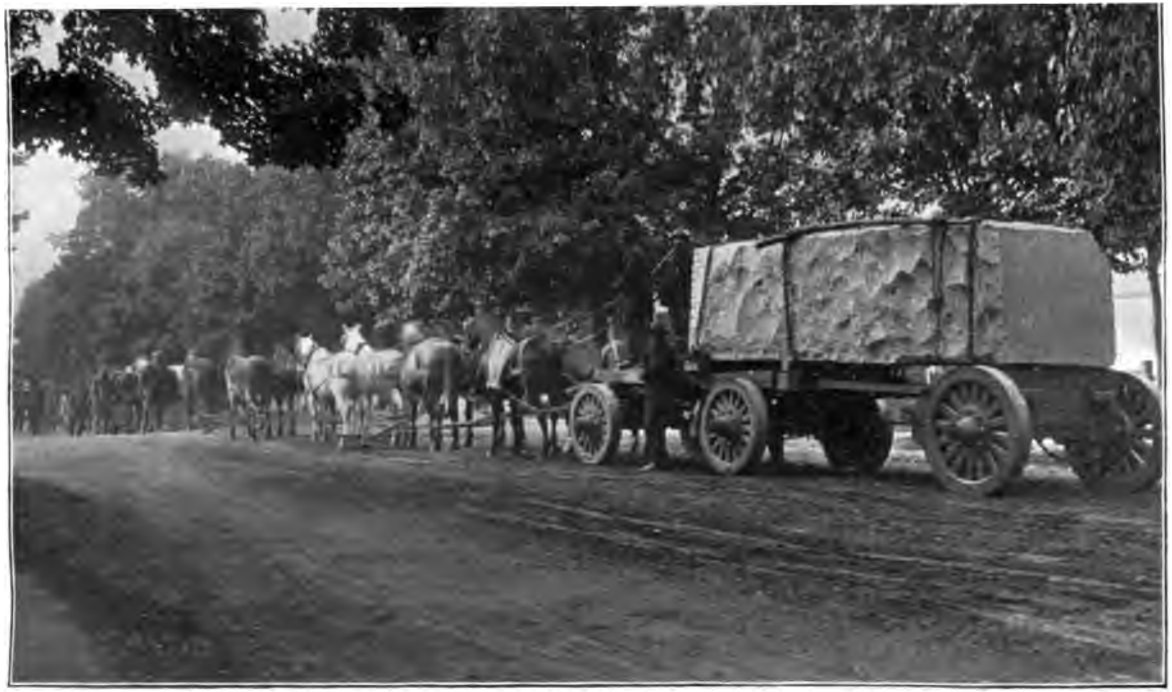


FIGURE 20. GRANITE TEAM DRAWING STONE FROM THE QUARRY,

ten or twelve acres. A railroad has been built from Ba the quarries which, though only a few miles in length, des to be classed with the scenic lines of the country for the g is very steep and, in consequence an, elevation is soon ga that allows of very extended and very beautiful outlook different directions. The greater part of the granite is conv from the quarries to the cutting and finishing works or to s ping points, by this road, which has branches running dire into some of the larger quarries, but in course of a year many t are carried down by teams like that shown in figure 20. As grade from the quarries to Barre is descending, large loads be drawn.

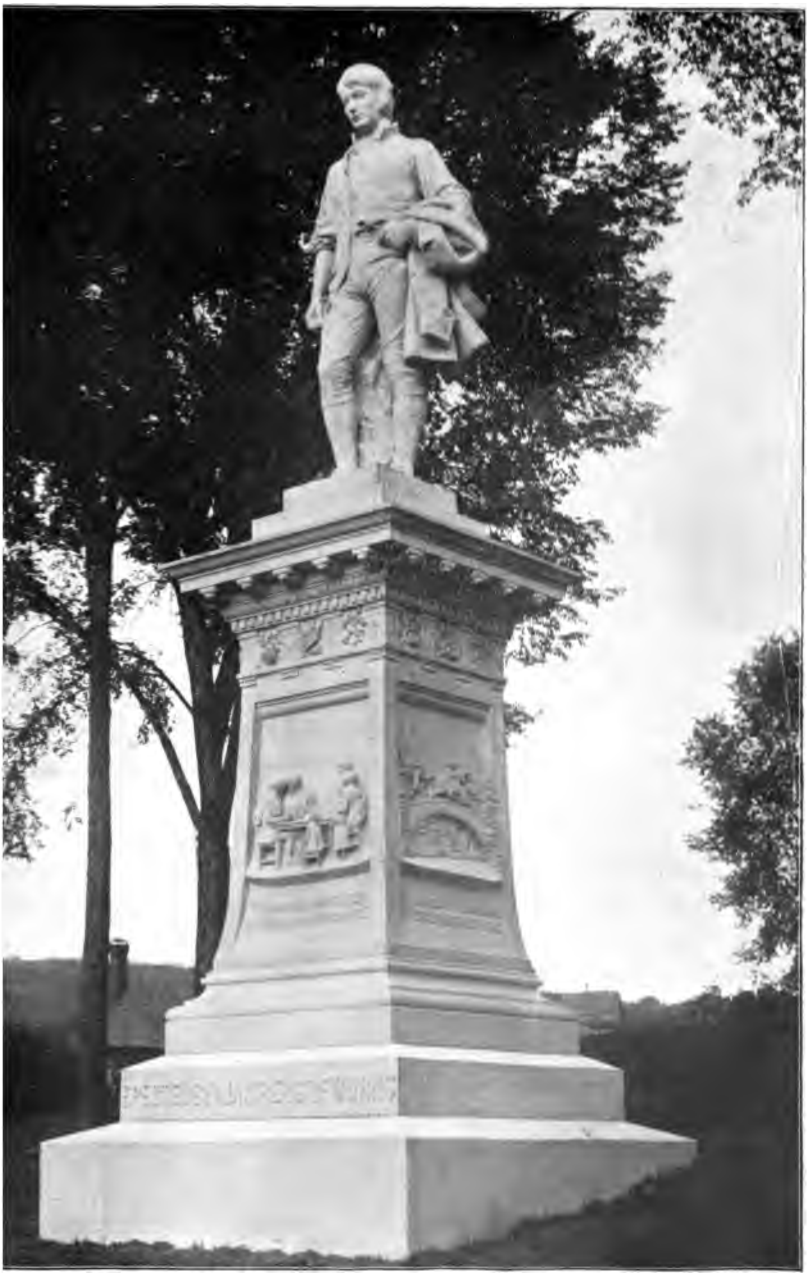
For figures 19 and 20, I am indebted to the Cummings Pri ing Company, St. Albans.

The great demand for monumental work in granite, caused the Barre companies to bring into their service workm capable of the best grade of work. It is not too much to s that many of these companies are able to take the rough blo of stone from their own quarry, and in their finishing work transform it into a monument that will well bear comparis with any in the country. As showing two of the best exampl of this, I have made use of the accompanying figures.

The Burns monument which stands in Barre is made whol of the local stone, was carved by Barre workmen and given to th city by the granite workers. It shows not only the excellen of the carver, but also, and it is mainly for this reason that have introduced the illustrations of it, the possibilities of t granite. Figure 21 shows the monument as a whole, giving t front and right side.

Figures 22, 23 and 24 give larger views of three of panels on the base and show better than the view of the wh the character of the carving. The scene on the front of t base is the Cotter's Saturday Night, the titles of the other th are given beneath the illustrations.

For the use of figure 21, I am indebted to Mr. E. W. Cu mings, Barre. For figures 22, 23 and 24 to the Burns Club, Barre



GURE 21. BURNS MONUMENT, BARRE. The entire monument is made of Barre Granite.

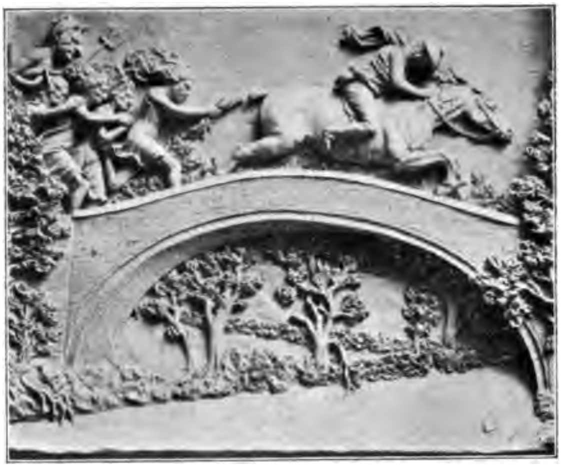


FIGURE 22. TAM O'SHANTER.

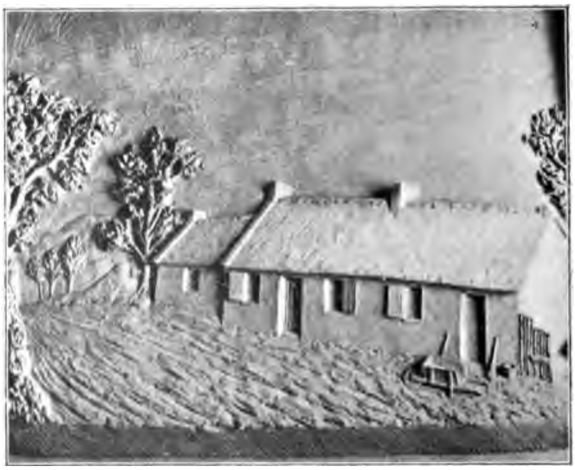


FIGURE 23. THE BURNS COTTAGE. PANELS CARVED IN GRANITE ON THE BURNS MONUMENT.

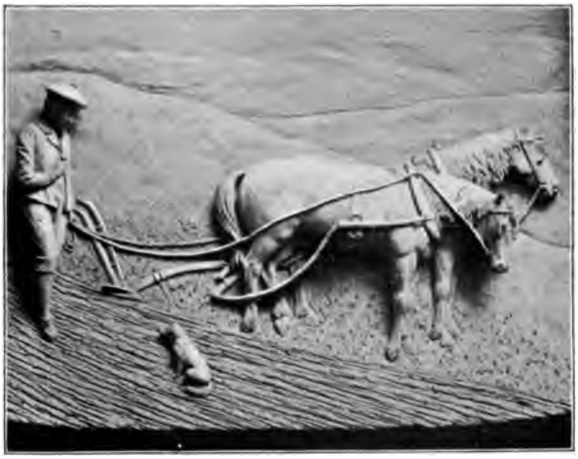


FIGURE 24. BURNS AT THE PLOW. PANEL ON THE BURNS MONUMENT.

Figure 25 shows a monument placed in a cemetery in Louisville, Ky., by Barclay Bros., which is also a fine specimen of both stone and work.

The bedding in the Barre quarries varies greatly from quite thin to very thick. There is often a considerable range in the same quarry, though some quarries are as a whole thin bedded while others are thick bedded. In some of the quarries the layers of stone are remarkably even, extending for many feet with very little variation in thickness or quality. Here, as at some of the Woodbury quarries, there seems to be no limit to the size of the blocks that can be quarried other than that of the ability of the workmen and derricks to handle them.

I saw in one of the quarries a block which had been detached from its bed and, therefore, in a condition to be moved if needed, which was sixty feet long, seven feet wide and six feet thick, and it would have been entirely practicable to get out many other blocks as large, had they been wanted. Out of the block in question, there was to be cut a shaft forty feet long and the rest cut off.

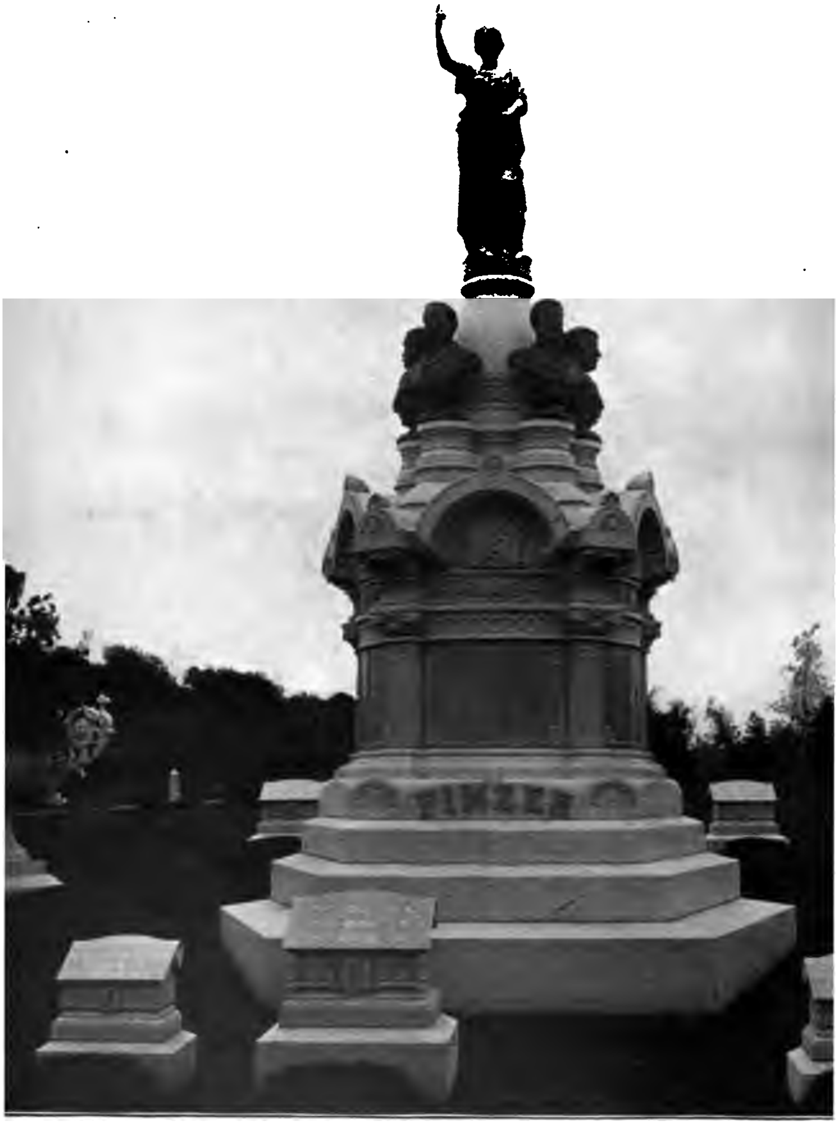


FIGURE 25. MONUMENT OF BARRE GRANITE.

Figure 26 shows a rather thin bedded quarry in the background, and on the cars is one of the longest shafts ever quarried n these quarries.

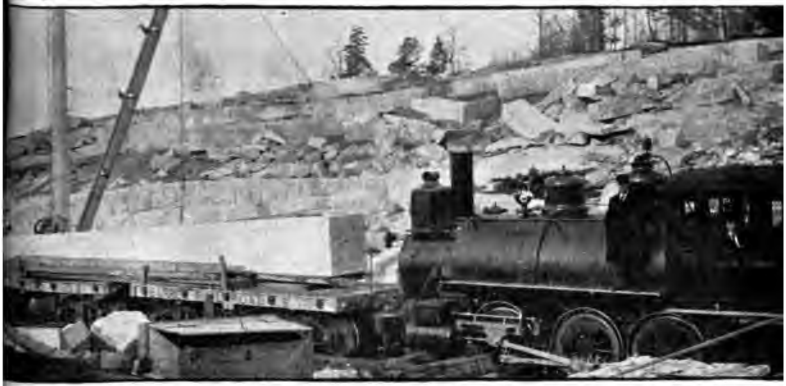


FIGURE 26. QUARRY OF WETMORE & MORSE, BARRE.

Figure 27 shows a moderately thin bedded quarry. In the oreground is a large mass quarried for the roof of a mausoleum.

I have not yet traced the granite belt in which the Barre arries are situated northward, but I think it very probable that e quarries at Woodbury are in the same belt. At any rate the one is similar in the two localities and there are quarries at alais which is between Barre and Woodbury. There are at esent about a dozen quarries in operation in Woodbury and merous finishing works in Woodbuury and Hardwick, especily the latter place where most of the stone quarried in Woodry is dressed. Like the Barre quarries, these, for the most rt, report good and increasing business. There is a railroad hich runs from the St. Johnsbury and Lake Champlain Road rough Hardwick and Woodbury to the quarries by which the one can be conveniently brought to the main line for shipping the rough or to the sheds for cutting. While this region can obably never equal Barre in the extent of its granite business, nevertheless seems certain to become an important center for e production of the stone. Figures 28 and 29 show one of

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the Woodbury quarries, that of the Woodbury Granite Company. This quarry, like others at Woodbury, is located on the side of a small mountain which appears to be largely composed of granite. The equipment of this quarry is reported as follows:

"A derrick capable of lifting 50 tons, operated by steam power both for lifting and turning; a derrick capable of lifting 25 tons, operated in the same way; two other smaller derricks operated by steam power, and one of the largest and most powerful locomotive cranes manufactured by the Industrial Works, Bay City, Mich., capable of switching five cars and lifting twelve tons, and is operated on the tracks in any part of the quarry. The quarry is also equipped with steam drills, both large and small sizes, and in fact with everything in the way of machinery to facilitate the quarrying and handling of blocks of granite of any size required. The sheets have been opened in an unusual manner in the last few months, and are now at work on four large sheets which lie one above the other. These sheets vary in thickness from 12 to 25 feet. Among the long breaks that have been made during the past season is one in a sheet 15 feet in thickness back 30 feet from the edge and 200 feet long; another fully 300 feet long, back from the face 12 to 15 feet and in a sheet from 15 to 20 feet thick. These breaks can be made at almost any time, and nearly all of them are capable of being extended when required."

The quality of the Woodbury granite appears to be equal to that found in any other locality. Some of the companies here report that their business has increased fifty per cent since 1898.

The only quarries with which I am acquainted, which are located in Hardwick, are those of the Standard Granite Company. These contain several varieties of granite, from very light to dark and is of good quality.

In the town of Sodom there are several granite quarries in operation. Some of these are increasing the equipment and expect to greatly enlarge their output the coming year. The stone from these quarries is reported to sell readily when placed upon the market.

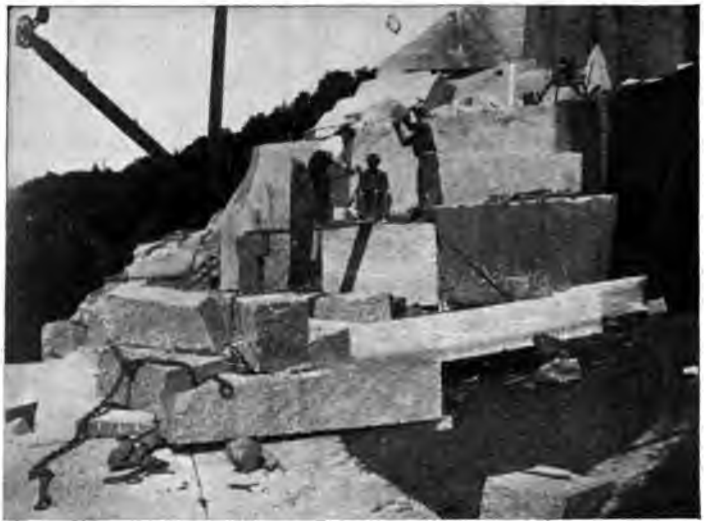

Figure 28. Quarry of the Woodbury Granite Company.

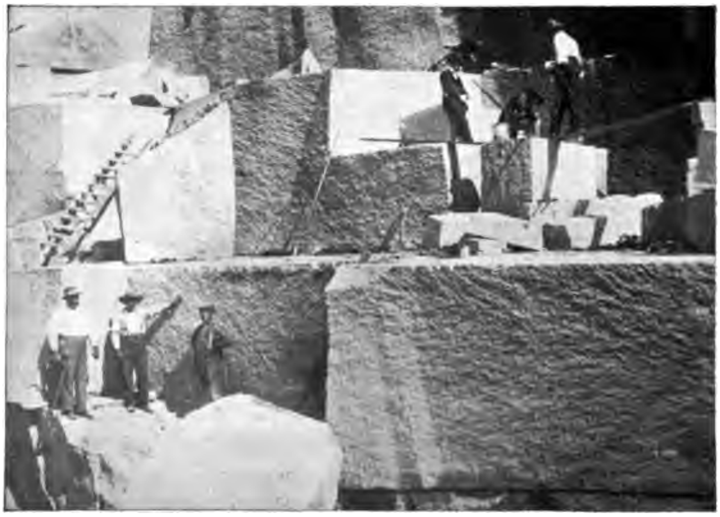

Figure 29. Quarry of the Woodbury Granite Company.

The Pine Mountain Granite Company of Groton have done some work during the past two years, and their quarry is being vigorously worked the present season. Pine Mountain is two hundred feet high and is over a hundred acres in superficial extent and contains a large supply of good granite. It is on the border between Groton and Topsham and the quarry is in the latter place. The stone from this locality seems to be of good quality, both light and dark, fine grained and coarser grained. Granite has also been quarried at Ricker's Mills, though not on a very large scale.

At South Ryegate, The Blue Mountain Granite Company has done some quarrying, and also at Topsham.

In Kirby, the Kirby Mountain Granite Company has within a few months opened a quarry and is pushing work on a large mass of stone.

In the extreme northern part of the state, the Standard Granite Company has recently opened a quarry formerly worked, but not for some years, at Beebe Plain.

The largest granite company outside of Barre is the George E. Lyon Granite Company, the office of which is at Brattleboro, but the quarry is at West Dummerston. A small illustration of this quarry may be found in the last Report, but it only imperfectly shows the character of the deposit. The quarry is a peculiarly long one and is situated directly on the side of a small mountain, It is what is called a sheet quarry and is most conveniently located, the stone being easily quarried and loaded on cars directly from the ledge. This is, however, true of a number of other quarries in the state. As in many of our quarries, there are found here both light and dark granite. The layers of granite are from one to twelve feet thick, and of the best quality. The quarry is well equipped, having thirteen steam derricks, five 20-horse power and one 50-horse power engines, steam drills, etc. The stone is taken from the ledges by an overhead trolley which can carry twenty tons per load and is capable of loading, hoisting and carrying six hundred tons a day.

About three miles from the village of Bethel there is a de-deposit of granite which has in past years been considerably worked, but not to a very great depth. It is a particularly thin bedded deposit, though very likely, if the deeper layers could be reached, they would be thicker. There is a great variety seen in the different layers, some of them being very coarse grained while others are finer and some very fine.

It is said to be a very durable stone and foundations of houses in the region may be seen that are perfectly sound which were put in over seventy years ago.

The Windsor Green Granite Company, the office of which is in Montpelier, have for some seven or eight years quarried a fine dark green syenite on the steep northern side of Mt. Ascutney. The quarry is high up on the mountain and the stone must be drawn by team down a steep descent for a mile or two and then three or four miles to the railroad. This stone is dark olive green and black. I know of no other quarry like it in the state.

The stone is not a true granite, but a syenite, the mica of granite being replaced by hornblende. It is, on this account, a harder stone than granite and takes a very fine polish. The best example of its use for interior work, is seen in the new Library of Columbia University. Here the great central dome is supported by columns of the Windsor "Green Granite." These columns are eighteen feet high and three and a half feet in diameter, though each is in several pieces. At present the quarry is being moderately worked, some three or four thousand feet of stone being annually taken out.

This stone is apparently of volcanic origin, as was noticed some years ago by Prof. Hitchcock. Mt. Ascutney is, at its highest point, about two thousand feet above the valley and somewhat more than three thousand feet above the sea level. The highest cone of the mountain is largely made up of the syenite flanked by schists and slates. According to Prof. Hitchcock, these adjacent rocks have been changed by the heat from the eruption of the lava which hardened into the syenite, for five hundred feet away from it. What this means is that at some time in the past, the mountain was an active volcano and that then the great mass which is now being quarried, was raised from the depths of the earth as molten lava.

SOAPSTONE, STEATITE.

This substance occurs in many localities in the state. It has been quarried to some extent in Waterbury, Athens, Bridgewater, Bethel, Cavendish, Marlboro, Newfane, Plymouth, Rochester, Townshend, Waterville, Windham and some other places, besides those to be mentioned more fully.

At present only a few quarries are in operation and these are all in a limited area. Beginning at Ludlow, the most northern quarry is a short distance south of the village. This quarry is practically a new one, though some work was done on the same deposit some 18 years ago. The quarry is now worked by Williams & Co. and, at the time I saw it, was well equipped and was being vigorously operated. A very promising bed of stone was exposed and large blocks were quarried. Near the quarry a steam mill was cutting the blocks into slabs, ordinary marble saws being used. Following the Black river for several miles, we come to the next soapstone quarry at Perkinsville. There are really two quarries here, for, just south of that now worked, there is an abandoned quarry from which a large amount of stone must have been taken in former times. The quarry now worked is said to have been in operation for fifty years or more. Indeed, it appears to have been more actively worked formerly than now, for Mr. Hager, in the Report of 1861, says that in 1859 about eight hundred tons of stone was taken out of this quarry which, I should think, is a larger amount than is now quarried, though I have not been able to get a definite report from either this quarry or that at Ludlow.

This quarry is at the top of a hill a mile perhaps from the village, near Baltimore. In the village there are two steam mills where the blocks drawn down from the quarry are sawed and made into sinks, tubs, etc. Here, instead of marble saws, toothed saws are used, the stone being considerably softer than that at the Ludlow quarry. Still the stone quarried at Ludlow is some of it cut into slabs here, as is that from the quarry at Grafton. The deposits of soapstone in Grafton and the adjoining town of Athens have been worked longer than those at Perkinsville. It is interesting to note that at first the soapstone was quarried and used much as if it were limestone or marble, for door sills, mantels, window caps, fireplaces and hearths, etc. For these purposes, the stone was gotten out at this locality more than eighty years ago. Although the softness of soapstone renders it more liable to injury than if it were harder, yet it is durable for inside work and the great ease with which it can be sawed or cut more than compensates, in many cases, for the softness.

Soapstone has also been quarried during the year at Chester. For some time soapstone was quarried at Cavendish, the quarry being on the road from Ludlow to Proctorsville. It is reported that a large amount of stone was taken out at this place and ground to be used in "asbestos" paint. The amount of soapstone quarried in the whole country is not large and I have not succeeded in ascertaining what portion of it comes from Vermont. In the Report of the United States Geological Survey on MINERAL RESOURCES for 1898–99, seven states are named as producers of soapstone, but Vermont is not one of them. This state, however, has for many years, as has been shown, produced this stone. Blanks were sent to all the quarries now worked in the state, but no reply has been returned from any of them, so that I cannot give the present production. The last statement which I am able to find gives the production in 1880 as worth $20,000.

Soapstone is a compact form of talc. When the mineral is less compact, and especially if it is foliated or fibrous, it is recognized as talc. Talc occurs in all parts of the state, there being over thirty localities. In several of these localities some attempt to mine talc has been made, but with discouraging results. The only mine which has ever amounted to much is that of the New

England Talc Company. The office of this company is in Worcester, Mass. The mine is in Stockbridge, about twelve miles from Bethel and three miles from Stockbridge village. This mine has been quite extensively worked by tunnelling into the deposit which is situated on top of a high and steep hill. Near the entrance to the tunnel there is an engine and machinery for grinding the mineral. There is also a very efficient overhead trolley by means of which the mineral can be easily sent down to the foot of the hill where it can be readily loaded on wagons.

At the time I visited this mine no work had been done in it since spring, 1899. Just what is the real reason for stopping work at this mine no one seemed to know. In the vicinity other beds of talc have been opened to some small extent, but no work of any importance has been done upon them.

KAOLIN.

Beds of kaolin are found in Monkton, Brandon, Wallingford, Bennington, Plymouth, and other places in the state. The principal beds that have been worked are those at Monkton and Brandon. Kaolin is used largely in the manufacture of china and other earthenware, and also for fire bricks. It also furnishes an important part in some kinds of paper.

At present the only bed of kaolin which is worked is that of the Monkton Kaolin Company. The office of this company is at Vergennes ; the clay is dug at the Monkton bed.

OCHRE.

Beds of ochre occur in the vicinity of some of the beds of iron and also of kaolin. During past years and in some cases until recently, these beds have been worked, but none are now in operation. In 1880 the ochre produced in the state amounted to 1750 tons valued at $27,750. In 1890 this amount had declined to about one fourth of the above, and since then the production has wholly ceased. The principal beds of ochre in the state are at Brandon, Shaftsbury and Bennington, though there are others of less importance.

The Rutland Fire Clay Company is doing a considerable business in digging clay which is prepared for use as lining for stoves.

The Pike Manufacturing Company of Brownington quarry a sort of quartzite which is made into scythe stones. The quarry covers about two acres and is twenty feet deep.

THE STATE CABINET

As Curator of the State Cabinet I have the honor to report as follows:

During the past two years the collections which were in the cases when I took charge of them have been very largely rearranged so that all allied forms are found together and a considerable number of new specimens, mostly such as were needed to complete series, have been purchased. Quite a number of specimens, some of them of much value and interest, have been given to the Cabinet.

Both in the arrangement of specimens and the selection of additions, I have constantly had in mind the fact that a great number of school children, as well as older persons, visit the Cabinet not merely to glance over the cases, but to study some group of animals or minerals. Hence it has been my aim to make the collections as useful as possible to these student visitors who often come with note books and who must surely carry away some information which they have gained from the specimens seen. I doubt if the people of the state realize the educational importance of the State Collections. They contain many valuable objects, but this alone would simply mean that here is a place of deposit where rare or interesting specimens may be cared for and preserved. Such a depositary the State Cabinet should be and is, but its educational value consists especially in the fact that during the year a very large number of persons of all classes and ages come to the rooms in which the collections are exhibited.

No count of the visitors during a fixed time has been made, but in course of a year several thousand spend more or less time in the Cabinet rooms.

The collections are first of all collections of Vermont objects, designed to illustrate the animal life and mineral wealth of our own state, but, as many very attractive and interesting objects are not found in Vermont, it has been considered wise to supplement in some limited measure our native animals and minerals by specimens illustrating groups not represented in a collection of Vermont specimens.

The collections themselves are of no inconsiderable value and deserve better accommodations. The two rooms devoted to them are too small and not well lighted. In any but the brightest days it is quite impossible to clearly distinguish the contents of many of the cases. If placed in larger and better lighted rooms the specimens would make a far finer appearance. A descriptive catalogue of the various objects displayed in the different cases would be of great assistance to those who desire to gain the utmost profit from an inspection of the museum and such a catalogue is already in process of preparation and it is hoped will be published as soon as completed. No such catalogue has ever been issued and, in lieu of it, the following brief summary of what is to be seen in the rooms will be of some assistance.

The south room contains the birds and mammals of Vermont, with only a very few from outside the state.

So far as is possible, the specimens are arranged according to the modern classifications. Most of the specimens are exceptionally well set up. In all, there are over three hundred birds and fifty mammals. Among these there are quite a number which could scarcely be duplicated, such as the Golden Eagle, Mocking Bird, Sand Hill Crane, Cross Fox, Silver Fox, Beaver, Otter, Panther, Seal and other species which are either extinct in this state or exceedingly rare. Of course all of the above are, at least now and then, taken in other regions, but these are all Vermont specimens.